A TAXONOMIC AND GEOGRAPHIC STUDY OF THE GENUS *XANTHOPARMELIA* IN THE KAROO

FRANKLIN ANDREJ BRUSSE

A Dissertation Submitted to the Faculty of Science,
University of the Witwatersrand, Johannesburg,
for the Degree of Master of Science.

April, 1980

DECLARATION BY CANDIDATE

I hereby declare that this dissertation is my own work and that it has not been submitted to any other university.

Brusso

ABSTRACT

A TAXONOMIC AND GEOGRAPHIC STUDY OF THE GENUS *XANTHOPARMELIA* IN THE KAROO

This study was undertaken to assess the variability of the common *Xanthoparmelia* species in the Karoo, to provide a meaningful taxonomy for these lichens, and at the same time to note floristic patterns of *Xanthoparmelia* in the area. To this end, approximately 900 specimens were collected from the area and subjected to chemical and morphological examinations. In addition, about 100 reference specimens, mainly types pertaining to *Xanthoparmelia* in southern Africa, were also examined.

Routine observations on the gross morphology of the specimens were carried out at ten times magnification, and the form of the epicortex on selected specimens was viewed with a scanning electron microscope. Light microscope work was performed on freezing microtome sections of apothecia and lobes, and hymenial and pycnial preparations from selected specimens of each major species. The type of rock substrate was noted, but no exclusive rock specificity was perceived for any of the common Karoo species. The chemistry of each specimen was routinely elucidated by means of thin layer chromatography and spot tests. Where necessary microhydrolyses and microcrystal tests were also carried out.

A total of 59 lichen substances were found in the Karoo Xanthoparmeliae, with usnic acid universal. Of the 27 of known chemical structure, 21 are β-orcinol compounds and only four are compounds of the orcinol series. This is in stark contrast to the genus *Neofuscelia* Essl. where orcinol depsides and depsidones are most common. The most frequent lichen substances besides pigments, are the β-orcinol depsidones salazinic (found in a total of 320 specimens), protocetraric (175), hypoprotocetraric

(160) and 4-O-demethylnotatic (120) acids. This represents two thirds of the entire collection. The only noteworthy orcinol compound in this respect is the depside lecanoric acid (50).

The range of morphological variation was found to vary from species to species. Several species, *X. adhaerens*, *X. brunnthaleri*, *X. colorata*, *X. columnata*, *X. dichromatica*, *X. endomiltodes*, *X. heterodoxa*, *X. ianthina*, *X. leptoplaca*, *X. psoromifera*, *X. ralla*, *X. schenckiana* and *X. squamatica* are conservative in their habit variation. Four species, *X. chalybaeizans*, *X. constrictans*, *X. perspersa*, and *X. worcesteri* are considered to vary from subcrustose to foliose. The remaining species show various types of foliose variation, one case (*X. molliuscula*) becoming fruticose, and others (*X. hyporhytida* and *X. subconspersa*) tending towards the habit of *Omphalodium hottentottum* (Ach.) Flot.

33 species of *Xanthoparmelia* in the Karoo are accepted in this study. *X. exornata*, *X. leptoplaca*, *X. perspersa*, *X. psoromifera*, *X. schenckiana*, *X. subconspersa*, *X. subdecipiens* and *X. worcesteri* are widespread in the area. Other species such as *X. brunnthaleri*, *X. chalybaeizans*, *X. colorata*, *X. dichromatica* and *X. tasmanica*, are common in certain parts of the Karoo. The remaining species are either uncommon or distributed in marginal areas. Four floristic zones are recognized in the Karoo proper, with two marginal zones included as well.

Descriptions, distribution maps and photographs are provided for all the species, and a key to them is presented. Five new species are described: *Xanthoparmelia dysprosa*, *X. ianthina*, *X. leucostigma*, *X. ralla* and *X. squamatica*. New combinations are *Xanthoparmelia burmeisteri* (Elix) Brusse, *X. exornata* (Zahlbr.) Brusse, *X. globulifera* (Kurok. et Filson) Brusse, *X. hypomelaena* (Vain. ex Lynge) Brusse, *X. leptoplaca* (Zahlbr.) Brusse and *X. perspersa* (Stiz.) Brusse.

ACKNOWLEDGEMENTS

The author would like to thank Dr. M.D.E. Knox for his guidance and valuable assistance during the course of this study. Thanks are due to the staff of the inter-library loans service, who provided copies of many articles not available at this University, and also to members of the Electron Microscope Unit for their help with the scanning electron microscopy. My gratitude is also extended to all those individuals who, in some small way, made the execution of this work practicable.

The opportunity to examine reference specimens was greatly appreciated and was made possible by the courtesy of the directors and curators of the following herbaria: BM, FH, G, GLAM, H, LD, PRE, TNS, TRH, TUR, VER, W and ZT.

The financial assistance of the University of the Witwatersrand is also gratefully acknowledged.

CONTENTS

Page

Page

LIST OF FIGURES, TABLES AND SCHEMES

Page

THE KAROO AND THE XANTHOPARMELIAE

1.1 INTRODUCTION

One of the most striking features of the dry interior of the Cape Province, is the profusion of lichen growth on suitable aspects of rock exposures. A conspicuous feature of many of these saxicolous lichen communities is the abundant presence of foliose lichens. In the area under consideration, these foliose lichens are representatives of the Parmeliae (sensu lato), to the virtual exclusion of other foliose groups. Of all the genera recently segregated from the formerly large genus *Parmelia* Ach. (Hale, 1974a, b, c, d; 1976b; Esslinger, 1978) only *Xanthoparmelia* (Vain.) Hale (1974d) *Pseudoparmelia* Lynge sensu Hale (1974a) and *Neofuscelia* Esslinger (1978) are regularly present. The Xanthoparmeliae are the dominant foliose lichens in terms of both total cover, and number of species present at each particular site. The Neofusceliae are the least abundant in terms of cover, although this impression is complicated by the presence of other crustose genera with brown cortical pigments, which may be confused with some subcrustose Neofusceliae, in the field.

Of the crustose genera present, the pale orange to red crustose members of the Teloschistaceae, such as *Caloplaca* Th. Fr., are very abundant. The conspicuous yellow species of *Acarospora (Xanthothallia)* Mass., are among the most drought resistant lichens growing in the Karoo, being sometimes the only genus present at particularly dry sites (Magnusson, 1929, 1933, 1956; Weber, 1968). Many other less easily recognized crustose genera also occur, the most prominent being *Lecidea* Ach. and *Buellia* de Not.

Any of the commonly occurring Karoo lichen genera would have been suitable for study, but the Parmeliae (*sensu lato*) had the sound base of the world-wide monographic works of Dr. Mason Hale and coworkers, and the most abundant of these, the Xanthoparmeliae, were chosen. The study was approached in the light of Magnusson's (1932) thesis: "What lichenology needs is not a name of each preserved specimen, the consequences of which are terrifying, but a survey of the variability of the species, founded if possible on studies in nature or at least on a large herbarium material." Little systematic collecting has been done in the Karoo and most of the *Xanthoparmelia* species occurring here are endemic to southern Africa.

The aim of the present study was therefore to gain insight into (a) the Karoo *Xanthoparmelia* flora, and (b) the variability and taxonomic status of its component species.

1.2 THE KAROO

The word Karoo is of Hottentot derivation meaning arid, hard and sparsely covered (Potgieter, 1972). It is commonly employed to indicate the dry interior of the Cape Province. The limits of the Karoo as used in this study are depicted in figure 1, and roughly correspond to those of the Karoo Domain (Werger, 1978a). Acocks (1979) gives a representation of the physiography of the area. The area is bounded by the course of the Orange river in the north and north-east; by the Kamiesberg, Roggeveld and Little Roggeveld mountains in the west; by the Witteberg and Swartberg in the south; and by the eastern Cape mountain ranges in the east (Fig. 1). Most of the area lies at moderate elevation, in southern African terms, between 600 and 1500 metres, and is prevalently flat terrain with scattered low hills or "koppies". Exceptions to this generalization do occur, however, the most notable being the presence of the Roggeveld to Sneeuwberg escarpment (1.4.3).

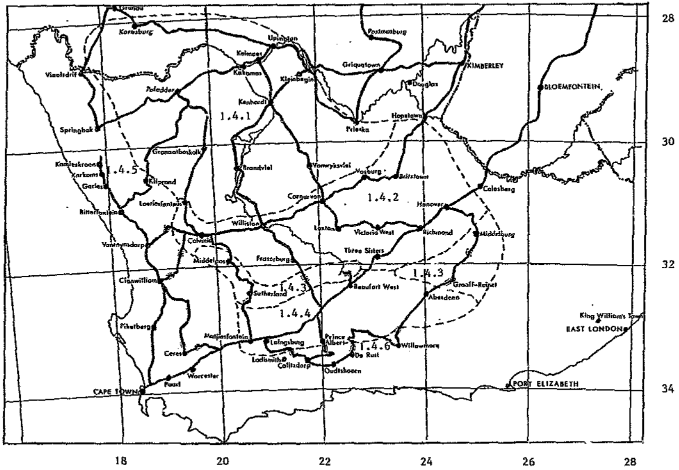


Fig. 1 Itinerary, with the Limits of the Karoo and Preliminary Floristic Zones.

1.2.1 Climate

(i) Temperature

The Karoo is typically thought of as a semi-desert with hot summer days and cold winter nights.

Mean radiation values vary from 11-16 $MJm^{-2}day^{-1}$ for the winter months, June to August, and from 27-29 $MJm^{-2}day^{-1}$ for the summer months December to February (Schulze and McGee, 1978).

The mean annual temperature varies from 14-20°C, being cooler in the south, and the mean annual range of temperature varies between 12 and 16°C from place to place, being greatest in the north-east of the Karoo (Schulze and McGee, 1978). Summer temperatures are high to very high, especially in the north, the mean monthly temperatures for January ranging between 20 and 28°C (Talbot and Talbot, 1960). Mean daily maximum temperatures for this month range from 28 to 35°C (Schulze and McGee, 1978). Mean monthly temperatures of 5 to 13°C are experienced in July (Talbot and Talbot, 1960), and the mean monthly minimum temperatures range from -2.5 to 7.5°C, from place to place during this month (Schulze and McGee, 1978).

The effect of temperature on the growth and survival of the Karoo Xanthoparmeliae is not known, but is expected to be minimal, as desert lichens have been shown to be tolerant of extremes in temperature (Kappen, 1973; McFarlane and Kershaw, 1978).

(ii) Rainfall

The mean annual precipitation varies from 50-250 millimetres, becoming progressively drier from east to west. Elevated areas are exceptions. (Trigonometrical survey office (a); Talbot and Talbot, 1960; Schulze and McGee, 1978).

The seasonality of the measurable precipitation also varies: (a) the area north and east of the line Willowmore-Prince Albert-Fraserburg-Pofadder-Aus receives more than 60% of its annual precipitation in summer (October to March); (b) the area between this line and the line Sutherland-Calvinia-Gamoep-Vioolsdrif can be designated the uniform rainfall area; and (c) the area between the latter line and the Atlantic coast receives more than 60% of its annual precipitation in winter (April to September) and can thus be regarded as the winter rainfall area (Werger, 1978b).

The rainfall in the Karoo is so sporadic, that it is unlikely to be important in the water relations of the native lichens in any direct way. There are reports that exposures to rainfall do not wet certain lichens due to heavy encrustations of lichen substances. These are assumed to depend on atmospheric humidity as a source of moisture (Blum, 1973, p. 383; Harris, 1976, p. 455).

(iii) Fog and Mist

Fog and mist are capable of wetting lichen thalli, and areas experiencing fog and mist usually show abundant lichen growth (Kappen, 1973). Mist occurs on the western and southern margins of the study area and to a lesser extent on the Roggeveld and Nuweveld escarpment. In places this may exceed precipitation (Schulze and McGee, 1978, pp. 35-36).

(iv) Dew

More important to the lichens in the Karoo is the more widespread and regular pre-dawn dewfall (Werger, 1978b). As observed for the northern extra-tropical area, where favourable places face north, the shaded aspect for this part of the globe (Kappen, 1973, pp. 355-357), the favoured aspect in the Karoo is south facing. A major exception to this rule is the western margin, where the mist factor overrides the dew effect, and most lichens grow on west facing aspects. Lange *et al.* (1970) have shown that net carbon dioxide assimilation occurs in the first 2-3 hours of light in the early morning when the lichens are moist because of dew. This early morning carbon fixation makes up for the considerable losses due to respiration at night, the excess forming lichen mass.

(v) Frost

Frost (or frozen dew) is common in the Karoo, occurring over a range of 0 to 80 days per annum. The number of days experiencing frost increases from the north to the Roggeveldberg-Sneeuwberg escarpment, where frost occurs most frequently. The Sutherland environs experience frost on more than 80 mornings per annum (Talbot and Talbot, 1950). Unlike higher plants, lichens appear to be resistant to damage in the frozen state, and there are reports that they can assimilate CO_2 at temperatures below zero degrees Celsius (Kappen, 1973, pp. 333-335).

(vi) Relative Humidity

Blum (1973) and Kappen (1973) cite several reports of lichens that are capable of absorbing water vapour from the atmosphere, without the presence of liquid water (in the form of dew, fog, mist or rain). They state that the precise mechanism of this absorption is not known, but is usually attributed to either hygroscopic absorption by gelatinous hyphal walls, or an active process, or both.

It also appears that net positive photosynthesis occurs at thallus moisture contents as low as 25 to 30% of dry weight, at least in some species (op. cit.). This moi~sture level is attainable in relative humidities below 100%. High rates of photosynthesis are apparent at 100% RH at least in some species. For instance *Ramalina maciformis* (Del.) Bory, at a RH of 100%, attains 80% of the photosynthetic rate achieved with wetted thalli. For some species, from a net carbon fixation point of view, water vapour intake is probably more effective than strong imbibition with liquid water, because in the latter case respiration may be higher (op. cit.; Harris, 1976).

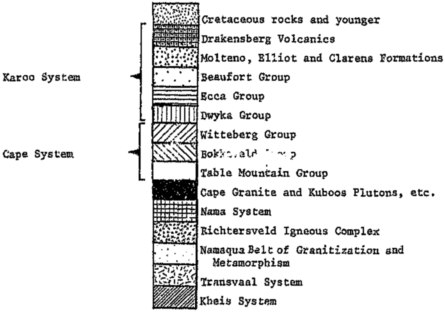
Ramalina celastri (Spreng.) Krog et Swinsc. and *Peltigera polydactyla* (Neck.) Hoffm. from the North Island of New Zealand, commence photosynthetic activity about 90% RH. Below the cut-off point for photosynthesis, respiration and sugar alcohol synthesis still continue. The tricarboxylic acid cycle and related protein synthesis seem to be desiccation tolerant, whereas the Calvin cycle appears sensitive (Cowan *et al.*, 1979).

Relative humidity data for the Karoo are few (Weather Bureau) and are difficult to interpret because RH values are recorded at specific clock times, and not for example at sunrise.

1.2.2 Geology

The surface geology of the Karoo is depicted in Figure 2. The basement of the southern tip of Africa can be considered to consist of two cratons, the Kaapvaal (>2500 million years old) and the Richtersveld (<2500 million years old) cratons. Around these stable cratons are regions that have undergone movement as evidenced by abundant faults and shear zones, called mobile belts (Truswell, 1977, p. 5). The Natal-Namaqua mobile belt which underlies much of southern South Africa,

Fig. 2 Geological legend



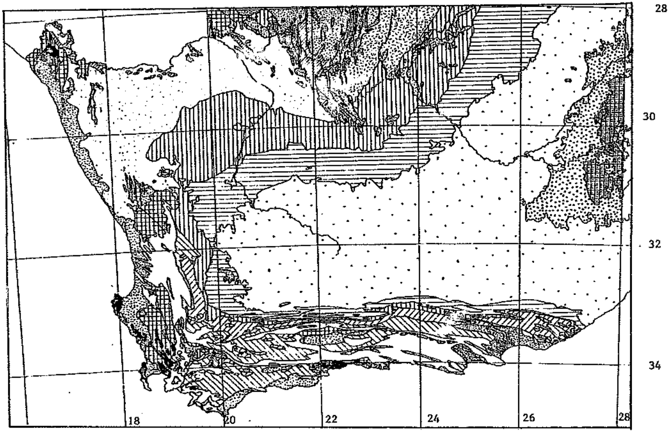


Fig. 2 Geological Map of the Karoo and Environs (After Talbot and Talbot (1960)).

may be of a similar age to the Richtersveld craton, but ages of around 1000 Ma are commonly obtained. This is thought to indicate an age of widespread regional metamorphism in this unit. This metamorphism is considered to have taken the form of a tectonic event (as a result of earth movement). Within the limits of the study area, the Namaqua granite-gneiss complex is the basement (floor) on which all other sequences ultimately rest (Stratten, 1971).

(i) The Namaqua Metamorphic Complex

The Namaqua granite-gneiss complex is exposed in the northern and north western parts of the Karoo (Fig. 2), and has been the subject of many recent investigation (Truswell, 1977; Botha *et al.*, 1976; 1977; Kröner and Blignaut, 1976; Blignaut, 1978; Stowe, 1979; Jack, 1979). Although the details of the complex geology of this area are still in the process of being elucidated, the area can be simplistically considered to be underlain by a basal granite-gneiss which supports supracrustal sequences with a varied stratigraphy yet similar overall lithology. The geology is more complex on the boundary zones, particularly between the Namaqua mobile belt and the Kaapvaal craton, (a 120 km-wide zone of NNW trending faults (Pretorius, 1974)).

Two approaches to the lithostratigraphic classification of these rocks over large areas have been adopted. The first has been to follow conformably overlain (unbroken successions of) rock strata, as done by Botha *et al.* (1976) for an area between the Langeberg range (on the Kaapvaal craton) and Kenhardt (on the Namaqua Mobile Belt). In this paper the similarities between the Matsap (on the Kaapvaal craton), the Kheis (borderline) and the Namaqua domains were stressed (Botha *et al.*, 1977, table 1), despite the increase in metamorphic grade and facies changes from east to west. The similarities between the

Kheis and the Orange river groups are well known (Truswell, 1977) and the similarities between the Richtersveld and Kheis provinces (sensu Kröner and Blignaut, 1976) have also been noted (Reid, 1977).

The second approach has been to divide up the area into geological provinces (Kröner and Blignaut, 1976) and treat them as separate geological entities. An even finer division has been used for areas between major megashear (mylonite) zones (see Botha *et al.*, 1977, fig. 4) which have been called tectonic divisions (Stowe, 1979).

The supracrustal rock types have been variously interpreted as metamorphosed igneous or sedimentary rocks. For instance the widespread quartzo-feldspathic rock is often referred to as "pink gneiss" implying igneous origin, but cross bedding has been reported in the "pink gneiss" west of Upington (Geringer and Botha, 1977b) indicating a possible sedimentary origin. A summary of the lithostratigraphy of this region will not be attempted, but references to the geology of the individual collection sites will be given where available (Appendix 5.1).

(ii) The Cape System

Most of the Karoo is underlain by sediments ranging from 440 to 160 million years in age. Two distinct sequences are present, the Cape and Karoo.

The Cape system is the older of the two systems, 440 to 300 million years BP, but is present only on the very margins of the Karoo. In fact the Cape system should be regarded as absent from the Karoo, but as some collecting was done from these rocks, the system will be discussed briefly. The Cape system is divided into the Table Mountain, Bokkeveld and Witteberg groups (Fig. 2).

(a) The Table Mountain Group

This lowermost group of the Cape system is up to 5 km thick in the southern Cape province and is mainly composed of coarse grained sandstones and orthoquarzites. Conglomerates, siltstone, glacial mudstone and minor shale are also present. Although the group is divided into a number of lithostratigraphic formations (Truswell, 1977, p. 115), most of the prominent relief features are built of one of these, the Peninsula formation, consisting of coarse grained orthoquarzite. Trace fossils are present, especially tracks and trails of presumed arthropod origin. Brachiopods, bryozoans, trilobites and crinoids have been found indicating a marine littoral origin for this group.

(b) The Bokkeveld Group

The Bokkeveld group is more complex and is represented by a series of alternating thicker shale and thinner sandstone units. The sandstone units of the upper half of the sequence pinch out from west to east, and all sandstone members pinch out towards the south, so that south of the line Caledon-Riversdale only shales and mudstones are developed, which also have a greater thickness (maximum 3.5 km). A littoral marine fauna (commonly pelecypods, brachiopods, and trilobites) is known also from the Bokkeveld, notably the shale units of the central area (Theron, 1971).

(c) The Witteberg Group

The first sandstone above the uppermost Bokkeveld shale unit is taken to be the lower limit of this group. This contact may become difficult to identify in the east, and the rather arbitrary nature of this division is sometimes heightened by the similar plant fossils found in both the upper Bokkeveld and the lower Witteberg. A change in transition metal minerals has been reported at this boundary (Theron, 1971). This uppermost group of the Cape system is the least known, but persistent lithostratigraphic units can be traced from west to east. Sandstones and quartzites are restricted largely to the middle of the sequence (but see Hiller and Dunlevey (1978)), the best known of these being the Wittepoort quartzite, traceable from the Witteberg in the west to at least Grahamstown in the east. Argillaceous rocks are prominent in the lower and upper Witteberg. Vascular plants, mostly lycopods, trace fossils and fossil ray-finned fish (palaeoniscids; from the upper shales) have been reported for the Witteberg.

(iii) The Karoo System

By far the greatest part of the study area is underlain predominently by argillaceous sediments ranging from 300 to 160 million years in age (Fig. 2). The Karoo system has been divided into three distinct groups in the study area, each with their own characteristics. The *Glossopteris* flora is present in all three groups, but otherwise the fossil fauna and flora vary from group to group.

(a) The Dwyka Group

The Dwyka rests on the Natal-Namaqua granite-gneiss basement, but some sediments older than the Dwyka may lie between these two. In the southern area, for instance, the Cape system intervenes (Stratten, 1971).

The Dwyka is divided into a lower indistinctly stratified or unstratified glacial unit and an upper shale unit (the Prince Albert Shales). The glacial unit consists of tillite (a rock composed of variously sized, subangular stones, which may be scratched or grooved, and set in an argillaceous matrix). Other rocks in this unit are boulder clay, siltstone, sandstone, conglomerate, some varved shale (shale of alternating sandy and argillaceous lamina), and graded sequences. Typical glacier markings on the floor and within the glacial unit are known from a number of localities (Truswell, 1977; Visser *et al.*, 1979). The Prince Albert Shale Formation is very similar to the overlying Ecca, but a white weathering carbonaceous layer (the White Hill Formation or the "white band") serves as a boundary marker between these two groups. A thin white weathering, grey chert layer caps this unit, and sometimes occurs just below this layer also.

Plant fossils include the *Glossopteris* flora, fossil wood, and a lycopod in the upper shale beds. The glacial beds have not yielded animal fossils, but the upper shales, and thin shale layers between the glacial beds have. Branchiopods, cephalopods, pelecypods, arenaceous foraminifera, sponge spicules, radiolaria, notocarid crustaceans, coprolites (fossilized excreta) and limulid tracks have been found. Vertebrates include *Mesosaurus* and palaeoniscid fish (Truswell, 1977; Visser and Loock, 1978).

(b) The Ecca Group

The Ecca consists largely of dark bluish grey to black shales which weather in a laminated fashion. Carbonate concretions are often present in the shale. Sandstone is developed at the margins of the basin and towards the top of the Ecca.

Animal fossils are rare, but fish scales, sponge spicules, echninoid remains, a cephalopod, coprolites, limulid (king/horse-shoe crab) tracks and other trace fossils are known. Plant fossils are common and include the *Glossopteris* flora, *Gondwanidium*, silicified wood and chondrites (fucoid-like imprints)(Anderson and McLachlan, 1976; Truswell, 1977; Visser and Loocke, 1978; Visser *et al.*, 1979).

(c) The Beaufort Group

The Beaufort is characterised by massive greenish-grey, bluish-grey or "red" argillaceous rocks which weather in a blocky manner and are generally called mudstones. Cross bedded sandstones are frequent in the Beaufort as are fining upward cycles, both of which are rare in the Ecca (in the study area). Remains of mammal-like reptiles (therapsids) are numerous, and have been used to divide the Beaufort into biolithostratigraphic units (Keyser, 1973; Keyser and Smith, 1979; Kitching, 1979). Unlike the Ecca, plant fossils are uncommon in the Beaufort, but the *Glossopteris* flora, *Phyllotheca* and fossil wood are known. Trace fossils of marine organisms are rare (Shone, 1978). The differences between the Ecca and the Beaufort are considered to reflect a change from deposition in a large body of water to generally continental (mainly fluviatile) conditions respectively.

The Ecca-Beaufort boundary is taken to be the first purple/"red" mudstone above the sandstone rich upper Ecca strata (Keyser *et al.*, 1979). In the northern part of the western Karoo basin, these sandstone rich strata were formerly included in the Beaufort. In the southern area, on the other hand, these sandstone rich strata were excluded from the "Beaufort", and even a few lower Beaufort strata were included in the former Ecca (op. cit.). The northern Ecca-Beaufort boundary has therefore had to be shifted south of the presently published position on the $1{:}10^6$ scale geological map of the Republic of South Africa and the Kingdoms of Lesotho and Swaziland (Uys and Enslin, 1970; Fig. 2). The location of the southern boundary is approximately correct on this map.

(d) Karoo Dolerite (diabase)

The post Beaufort sediments, the Molteno, Elliot and

Clarens formations are not present in the study area (Figure 2), but hypabyssal activity related to the Drakensburg volcanics, caused widespread intrusion of dolerite into all types of existing rocks. The dolerite intruded the Karoo system in the form of dykes and sills and is being exposed by the weathering of the surrounding (softer) Karoo strata. The sills are responsible for the typical flat topped appearance of hills (koppies) in the area. Other rocks, such as Namaqua granite-gneiss have been intruded in the form of dykes only. Ages of 155 to 190 Ma have been recorded for the dolerite.

From this time onwards phases of plate tectonics (movement of the continental plates or "continental drift", by the spreading of the sea floor from the mid-oceanic ridges outwards), were initiated and Gondwanaland was disrupted.

(iv) Geology and the Xanthoparmeliae

The rock substrate specificity of many lichen species has been reviewed by Brodo (1973) and James *et al.* (1977). The limestone, dolomite and marble specificity of certain lichens (termed obligate chalcophiles) is well known, but the specificity on other basic rocks is less well documented. Limestone, dolomite and marble are essentially absent from the Karoo, but dolerite (a basic igneous rock) is common. Other rocks in the area are acidic. All species found in districts where these two rock classes occur were found to grow on both. However the typical Karoo species *X. brunnthaleri* and *X. leptoplaca* were found frequently on dolerite, and sporadically on acidic rocks. The marginal *X. hypoleia* usually occurred on acidic rock, but was found on dolerite near Louriesfontein. The paucity of basic rock exposures within the distribution range of *X. hypoleia* obviously influences this frequency.

Clarens formations are not present in the study area (Figure 2), but hypabyssal activity related to the Drakensburg volcanics, caused widespread intrusion of dolerite into all types of existing rocks. The dolerite intruded the Karoo system in the form of dykes and sills and is being exposed by the weathering of the surrounding (softer) Karoo strata. The sills are responsible for the typical flat topped appearance of hills (koppies) in the area. Other rocks, such as Namaqua granite-gneiss have been intruded in the form of dykes only. Ages of 155 to 190 Ma have been recorded for the dolerite.

From this time onwards phases of plate tectonics (movement of the continental plates or "continental drift", by the spreading of the sea floor from the mid-oceanic ridges outwards), were initiated and Gondwanaland was disrupted.

(iv) Geology and the Xanthoparmeliae

The rock substrate specificity of many lichen species has been reviewed by Brodo (1973) and James *et al.* (1977). The limestone, dolomite and marble specificity of certain lichens (termed obligate chalcophiles) is well known, but the specificity on other basic rocks is less well documented. Limestone, dolomite and marble are essentially absent from the Karoo, but dolerite (a basic igneous rock) is common. Other rocks in the area are acidic. All species found in districts where these two rock classes occur were found to grow on both. However the typical Karoo species *X. brunnthaleri* and *X. leptoplaca* were found frequently on dolerite, and sporadically on acidic rocks. The marginal *X. hypoleia* usually occurred on acidic rock, but was found on dolerite near Louriesfontein. The paucity of basic rock exposures within the distribution range of *X. hypoleia* obviously influences this frequency.

Various physical and chemical properties of rocks have been reported to affect lichens, such as mineral content, rock hardness, surface texture, porosity and water-holding capacity, colour and thermal properties (Wirth, 1972). The rate and mode of weathering may also be important.

1.2.3 Vegetation

The Karoo was first recognised as a phytogeographic unit by Harry Bolus (1875), but has since been defined in many ways (Werger, 1978a). The Karoo as used in this dissertation, corresponds roughly to the area called the Karoo domain (op. cit., p. 158). As the vegetation is thought to reflect the climatic conditions to which it is exposed, the Karoo domain (or simply Karoo) was chosen as a suitable area for the study of the common foliose lichen genus *Xanthoparmelia*. Besides the characterisation of a collection area and the modification of climate, the higher plant vegetation is unlikely to have any specific effect on saxicolous lichens, and therefore will be discussed only briefly.

The following summary is based on the accounts of Acocks (1975, 1979), Knapp (1973), and Werger (1978b). Abundant dwarf scrub with low cover value is typical of the Karoo. Trees are practically absent, except sometimes along water courses (mostly *Acacia* and *Rhus* species). Grasses, although present, are not usually a dominant feature of the vegetation, but may become so in the eastern and northern parts of the area in exceptionally wet seasons. The grass community species composition differs from grasslands in the eastern half of the country, and some species are essentially endemic to the Karoo and southern South West Africa (e.g. *Stipagrostis* spp. and *Enneapogon* sp.). Other grasses are shared with dry grasslands of the surrounding areas in the north and east. The Mesembryanthemaceae become increasingly common towards the southern and western margins. Most plants are members of the Liliaceae, Amaryllidaceae, Chenopodiaceae (*Salsola* spp.), Aizoaceae, *Portulacaceae*, Capparaceae, Crassulaceae, Fabaceae, Geraniaceae, Zygophyllaceae, Aitoniaceae, Euphorbiaceae, Ebenaceae, Asclepiadaceae, Solanaceae, Scrophulariaceae, Bignoniaceae (*Rhigosum* spp.) Acanthaceae, and especially Asteraceae.

1.3 MATERIALS AND METHODS

The present study was based on a field collection of about 900 *Xanthoparmelia* specimens, collected by the author from the Karoo during August 1976 and February 1977. About one hundred reference specimens, mostly types pertaining to *Xanthoparmelia* in southern Africa, have also been examined. These were obtained on loan by the kind courtesy of the directors and curators of the following herbaria (Abbreviations as in Holmgren and Keuken, 1974): BM, FH, G, GLAM, H-NYL, LD, PRE, TNS, TRH, TUB, TUR, VER, W and ZT.

1.3.1 Collection:

The study area was visited in a light motor vehicle and the routes were chosen to ensure, as far as possible, an even coverage of the whole of the Karoo (Fig. 1). Suitable collection sites were selected while travelling and were normally no more than two hundred metres from the road. The collection sites were pinpointed using appropriate 1:50,000 ordinance survey maps (Trigonometrical Survey Office (b)) in conjunction with field data. Route and direction of travel, mileage from nearest town, turnoff or river, and recollection of the general relief of the site, and other features, such as nearby homesteads, were used for this purpose. Most sites were conspicuous enough to be recognized on these maps and thus to be located accurately. However, some sites were so featureless as to make identification and certain location impossible, and these have been positioned to the nearest minute (1.6 - 1.8 km).

Various numbering systems were considered, but the simplest was felt to be a system based on collection site number. The collection site number was based on the date of collection and the number of the particular collection stop. For example the nth specimen collected at the kth collection stop of, say the 8th of February 1977, was labelled 772 8-k-n. Although a little unwieldy, it was preferred to a continuous numbering system since the place of collection could be recognized at a glance.

Most of the Karoo Xanthoparmeliae vary from being tightly adnate to subcrustose on the rock substratum, and the only way in which intact thalli could be collected was to collect the rock substrate as well. This required the use of a one kilogramme hammer and a cold chisel, which allowed many rocks to be sampled accurately. However the widespread Karoo dolerite, quartzite and some granitic/gneissic rocks were extremely hard, and thalli on flat faces of large boulders or outcrops of these rocks were unavailable for collection by this method. Advantages of this method were that complete specimens could be obtained, mixed thalli were not a problem and the rock also served as a substrate record. A major disadvantage of this method was the weight and bulk of the specimens, which created problems of transport and storage.

The rock specimens were wrapped in newspaper, taped up and numbered at the collection sites. The newspaper prevented abrasion of the thalli during transport. The numbers on the newspaper wrappings were later transferred to the rock, using white indian ink which was varnished over when dry.

Loosely to moderately adnate specimens were most conveniently collected in packets. However because of the reduction in bulk and weight, and the ease of curation and storage of packeted specimens, many tightly adnate specimens were also collected in this way. This allowed a better and more complete sample to be taken from each site. However the method had several disadvantages.

(a) Subcrustose Xanthoparmeliae cannot be packeted without the rock substrate;

the k^{th} collection stop of, say the 8th of February 1977, was labelled 772 8-k-n. Although a little unwieldy, it was preferred to a continuous numbering system since the place of collection could be recognized at a glance.

Most of the Karoo Xanthoparmeliae vary from being tightly adnate to subcrustose on the rock substratum, and the only way in which intact thalli could be collected was to collect the rock substrate as well. This required the use of a one kilogramme hammer and a cold chisel, which allowed many rocks to be sampled accurately. However the widespread Karoo dolerite, quartzite and some granitic/gneissic rocks were extremely hard, and thalli on flat faces of large boulders or outcrops of these rocks were unavailable for collection by this method. Advantages of this method were that complete specimens could be obtained, mixed thalli were not a problem and the rock also served as a substrate record. A major disadvantage of this method was the weight and bulk of the specimens, which created problems of transport and storage.

The rock specimens were wrapped in newspaper, taped up and numbered at the collection sites. The newspaper prevented abrasion of the thalli during transport. The numbers on the newspaper wrappings were later transferred to the rock, using white indian ink which was varnished over when dry.

Loosely to moderately adnate specimens were most conveniently collected in packets. However because of the reduction in bulk and weight, and the ease of curation and storage of packeted specimens, many tightly adnate specimens were also collected in this way. This allowed a better and more complete sample to be taken from each site. However the method had several disadvantages.

(a) Subcrustose Xanthoparmeliae cannot be packeted without the rock substrate;

(b) The thalli had to be well developed and isolated in order to obtain a sample of reasonable size and purity (This was a very real problem in many instances where thalli grew intermingled or in close proximity to one another);

(c) The resulting specimens, for the majority of cases, were little more than a mass of lobe fragments.

On the February 1977 collecting excursion, a compromise was made between the two collection methods, approximately a third of the specimens being on rock and the remainder in packets.

Lastly, the aspect of the collection site, or the aspect with the most abundant lichen or *Xanthoparmelia* growth, was recorded using a compass. In most cases, the aspect with the most abundant lichen growth was also that with the most abundant *Xanthoparmelia* growth. In addition, a qualitative description of the locality was recorded (Appendix, 5.1).

1.3.2 Light microscopy:

The lichen specimens were examined routinely under a low power binocular dissecting microscope (Vickers instruments, York), using direct lighting. Observations were made usually at ten times magnification, but thirty times magnification was also employed on occasion. All chemical spot tests were performed with the aid of this instrument.

For internal anatomical studies, 15-20 µm thick sections were prepared using a Leitz-Wetzlar freezing microtome. Several staining procedures were evaluated, but the most satisfactory stain for the purpose of this study was found to be a 1% aqueous phloxine solution. Irrigation with 50% aqueous glycerol removed the excess phloxine stain, and rendered the preparation semipermanent (Korf, 1973). This procedure stained the cytoplasm pink and the walls and gelatinous material remained clear. Lobes were sectioned longitudinally and apothecia radially. Normally the upper cortex was obscured by a 10-30 µm thick region impregnated with usnic acid, which appeared dark under the light microscope. This was removed by irrigating the sections with 80% aqueous acetone. This rather drastic treatment appeared to damage the algal cells, and minute vapour/air bubble artifacts were produced on rough surfaces (plate 7A & B). However the fungal component appeared unaffected in comparison with the untreated controls. Apothecial sections were first stained with Lugol's iodine, and hymenial observations and measurements carried out. The phloxine stain was then applied to show up the paraphyses and general apothecial anatomy. Phloxine causes the blue colour of the ascal walls to disappear over a period of ten minutes or longer. Melzer's iodine reagent was found unsuitable due to the variability of staining, in some cases only a weak blue reaction being produced.

Ascospore squashes were prepared from hymenial scrapings as follows: The hymenium was first moistened with water delivered into the cup of the apothecium by means of a pair of watch-maker's or electron microscope (EM) forceps. The EM forceps were dried on blotting paper and then used to scrape off a portion of the hymenium. The scrapings were then transferred to a drop of stain on a microscope slide and ground using a second slide till the dark scrapings were no longer discernable and the stain became cloudy. If the hymenium was allowed to soak in water for longer than a few minutes, it became difficult to remove cleanly, due to the softening of the underlying tissue.

Pycnoconidia were prepared for light microscopy, by trimming the lobe tissue near a pycnium, using a sharp blade, and removing the exposed pycnium with EM forceps. A squash mount was then prepared using phloxine as the stain. If observed in conjunction with a blue or green filter the pycnoconidia showed up very clearly. A less distructive method of obtaining pycnoconidia is to moisten the thallus in the vicinity of pycnia with water, which causes the mucilage inside the pycnia to swell and a mass of pycnoconidia to be extruded from the ostioles in the form of small drops (Vobis, 1977). These small drops can be removed with EM forceps and transferred to a small drop of stain and observed as before.

For light microscopy, Zeiss and H & C (Katzenfurt/Wetzlar) [illegible] microscopes were used, with magnifications ranging from one hundred to one thousand times.

1.3.3 Scanning Electron Microscopy (SEM)

The material to be viewed was mounted on suitable SEM stubs using an ethanolic suspension of graphite. The mounted material was cleaned using compressed air, and air dried over phosphorus pentoxide in a desiccator for a least 24 hours. The stubs were then sputter coated under vacuum with gold-palladium, and kept in an air- and dust-proof container over silica gel desiccant, until they were viewed. A JEOL JSM T20 scanning electron microscope was used for viewing this material.

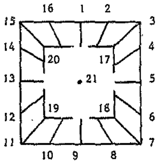
The materials and methods used to elucidate the lichen substance chemistry of the specimens will be discussed in the following chapter.

1.4 FLORISTICS OF *XANTHOPARMELIA* IN THE KAROO

The species composition of each site of collection is given in Appendix 5.2. Each major species is represented in Figure 3 by a symbol arranged in the space of a quarter degree square (Key to Figure 3). Sometimes two collections were made in the same quarter degree square and these are both represented in the same quarter degree square in Fig. 3. As the type and aspect of exposure, if any, differs from site to site, so the species composition and relative abundance of these species may vary from one site to the next, even though they may be close together and have the same climate and geology (Appendix 5.1). The availability of water as mist, dew and high relative humidity and the presence of shade (especially in the first few hours of light) are probably the most important factors for the growth of lichens in the Karoo, with an annual water deficit of 4 to 10 dm (Schulze and McGee, 1978, pp. 46-48). Thus sites high up on prominent relief features such as mountain ranges and escarpments, show abundant lichen growth on appropriate aspects. Others,near water courses or near ground water seepages, may show unusually rich lichen growth on favourable aspects in the immediate vicinity. This local effect of water on lichen abundance is presumably caused by increased transpiration by the local higher plant population due to increased water availability and a lower value of (less negative) soil water potential. It is possible that on still nights, the atmosphere attains high relative humidities as a result of this transpiration. More dew is thus expected to condense out of the atmosphere as it cools down beyond the dew-point in the early hours of the morning (Monteith, 1975). This is of frequent occurrence in the Karoo as radiation loss is high due to scant cloud cover on most nights.

Fig. 3 *Xanthoparmelia* floristics in the Karoo

Key:



1. *X. worcesteri* (J. Stein.et Zahlbr.) Hale
2. *X. scabrosa* (Tayl.) Hale
3. *X. leptoplaca* (Zahlbr.) Brusse
4. *X. psoromifera* (Kurok.) Hale
5. *X. brunnthaleri* (J. Stein.et Zahlbr.) Hale
6. *X. dichromatica* (Hale) Hale
7. *X. schenckiana* (Müll.-Arg.) Hale
8. *X. globulifera* (Kurok. & Filson) Brusse
9. *X. colorata* (Gyel.) Hale
10. *X. adhaerens* (Nyl.) Hale
11. *X. tasmanica* (Hook.f.et Tayl.) Hale
12. *X. hypomelaena* (Vain.ex Lynge) Brusse
13. *X. constrictans* (Nyl.) Hale
14. *X. hypoprotocetrarica* (Kurok.et Elix) Hale
15. *X. hypoleia* (Nyl.) Hale
16. *X. columnata* Hale
17. *X. exornata* (Zahlbr.) Brusse
18. *X. perspersa* (Stiz.) Brusse
19. *X. chalybaeizans* (J. Stein.et Zahlbr.) Hale
20. *X. subconspersa* (Nyl.) Hale
21. *Omphalodium hottentottum* (Ach.) Flot.

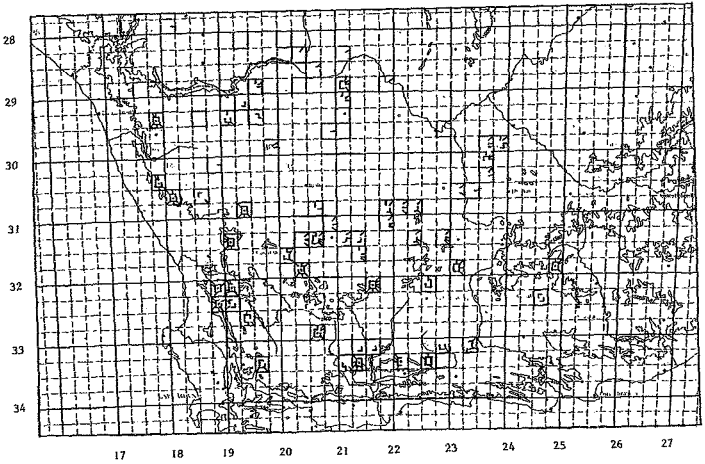


Fig. 3 *Xanthoparmelia* floristics in the Karoo

Another cause for the variability of site species composition may be the accuracy of sampling. In this respect the August 1976 collection is less reliable than the February 1977 collection. The latter collection usually contained several specimens of each species from each site, and can thus be regarded as reasonably complete. In addition specimens on rock may have various amounts of other species with them. These rocks were examined thoroughly for signs of other species, and in several cases small amounts to traces of a species are the only record of that species at particular sites. However in most cases these remnants of thalli represented species already collected.

With the above factors in mind the *Xanthoparmelia* flora of the Karoo can be broadly classified into the following units (Fig. 1):

1.4.1 The Northern Karoo

This area is approximately defined as those areas of the Karoo north of 31°S and west of 23°E but excluding the Kareeberg in the south east. It is characterized by very hot summer days, with the exposures of the Namaqualand metamorphic complex often bearing no Xanthoparmeliae. The southern part is underlain by the Dwyka and Ecca groups, but these are poorly exposed. Typical Xanthoparmeliae are *X. brunnthaleri*, *X. psoromifera* and *X. scabrosa*. Less frequent species are *X. chalybaeizans*, *X. exornata*, *X. perspersa*, *X. schenckiana*, *X. subconspersa*, *X. subdecipiens* and *X. worcesteri*. In addition *X. subramigera* is known from the Namiesberg.

1.4.2 The Central Karoo

This area extends from 31°S to the Roggeveld-, Nuweveld-, Sneeuwberg escarpment, and from 23°E to the Orange river, and includes the

Kareeberg. Exposures of the Ecca and Beaufort groups are fairly common, and dolerite koppies are numerous.

X. brunnthaleri, X. dichromatica, X. leptoplaca, X. persperaa, X. schenckiana and *X. worcesteri* are frequent and characteristic of this area. Less frequent species are *X. chalybaeizans, X. exornata, X. psoromifera, X. subconspersa*, and *X. subdecipiens*. Also very numerous are several species of *Caloplaca*, with the red *C.haematodes* (Mass.) Zahlbr. most conspicuous.

1.4.3 The Roggeveld- to Sneeuwberg Escarpment

This escarpment consists of good exposures of the Beaufort group and dolerite, and the Xanthoparmeliae are abundant. The central part of this escarpment (north-east of Beaufort West) has been weathered and should probably be included in 1.4.2.

Common species are *X. chalybaeizans, X. exornata, X. leptoplaca, X. persperaa, X. psoromifera, X. schenckiana, X. subconspersa, X. tasmanica, X. worcesteri* and *O. hottentottum*. Other elements such as pale undersurfaced forms of *X. colorata* are present in the Roggeveld and Nuweveld ranges, and *X. heterodoxa* is present in the Sneeuwberg. Less common species are *X. dichromatica* and *X. subdecipiens*.

1.4.4 The Southern Karoo

This area is known geographically as the Great Karoo. It lies between the base of Roggeveld-Nuweveld-Sneeuwberg escarpment and the Witte- and Swartberg. Most of the area is underlain by the Beaufort group but is lacking in relief features, and was sampled sporadically as a result.

Species found are *X. persperaa, X. leptoplaca, X. schenckiana, X. subconspersa*, and *X. worcesteri*, with *X.chalybaeizans, X. colorata*, *X. tasmanica* and *O. hottentottum* occurring on better exposures in the western part of this area.

1.4.5 The Western Margin

On the whole, the aspect with the most abundant lichen growth on this margin is west facing. Lichens are prolific on these mountains, including the Xanthoparmeliae. Frequent species are *X. chalybaeizans*, *X. colorata*, *X. columnata*, *X. exornata*, *X. hypoleia*, *X. perspersa*, *X. schenckiana*, *X. subconspersa*, *X. tasmanica*, *X. worcesteri* and *O. hottentottum*. The southern half of this margin differs from the northern half in being somewhat wetter and prominent relief features are exposures of the Cape system rather than Namaqua metamorphic complex. Several additional species are present in the southern half:- *X. adhaerens*, more tightly adnate forms of *X. constrictans*, *X. dysprosa*, *X. globulifera*, *X. hypomelaena*, *X. hypoprotocetrarica*, *X. ianthina*, and *X. squamatica*.

1.4.6 The Southern Margin

The mountains on this margin are exposures of the Cape system. Lichens are very abundant on these mountains, with the Xanthoparmeliae being a major component. Species present are: *X. adhaerens*, *X. chalybaeizans*, all forms of *X. constrictans*, *X. dichromatica*, *X. endomiltodes*, *X. exornata*, *X. globulifera*, *X. heterodoxa*, *X. hypoleia*, *X. hypomelaena*, *X. hypoprotocetrarica*, *X. ralla*, *X. subconspersa*, *X. subdecipiens*, and *O. hottentottum*. *X. colorata*, *X. perspersa*, *X. schenckiana*, and *X. worcesteri* occur at drier sites on this margin.

2. CHEMISTRY

2.1 THALLUS COLOUR REACTIONS OR SPOT TESTS

The first attempt at chemotaxonomy in lichens was made by Nylander (1866 a & b, 1867) when he showed that potassium hydroxide and calcium hypochlorite solutions yield colours with certain lichens. Although great emphasis was subsequently placed on these colour reactions in the determination of species, the structures of the compounds causing these reactions remained unknown until the turn of the century (Zopf, 1907, 1908). The reaction colours are somewhat variable and similar colours may be produced by several lichen substances. Despite this insensitivity, the spot tests are useful for the confirmation of the presence of certain lichen substances.

In this study the various solutions were delivered using electron microscope forceps, which could be manipulated to deliver very small amounts of the appropriate solution, even to very small lobe fragments. Four spot reagents were routinely used, and were applied to the medulla unless stated otherwise.

2.1.1 *PARA*-PHENYLENEDIAMINE P(1,4-diaminobenzene)

A 1% aqueous solution of this reagent, prepared by the method of Steiner (1955) (see appendix 5.3), was found to be most suitable. In this form the reagent is less hazardous to the user than an ethanolic solution, although colour production not only takes longer but also differs slightly. The colours are caused by Schiff's bases, formed by the condensation of aromatic aldehydes with p-phenylenediamine, and range from yellow to deep red.

In the lichens aromatic aldehydes are invariably β-orcinol depsides and depsidones, which sometimes react with K as well.

2.1.2 POTASSIUM HYDROXIDE, K

This reagent is usually applied to the medulla as a 10% aqueous solution, but may also be applied to the upper surface, as some minutely felty species have lichen substances in this region. The colour response varies from yellow (e.g. stictic acid) to blood-red (e.g. salazinic acid), and several weak reactions occur also (see 2.5). Most K+ substances are β-orcinol depsides and depsidones (the reverse is not true) and many are P+ as well. In this case the mode of colour formation is not understood.

The anthraquinone skyrin changes from orange to violet in strong base (K), the latter being the colour of the conjugate base (of skyrin). Other pigments with yellow to red to violet tones have been suspected to be anthraquinones if they give K+ violet to purple reactions.

2.1.3 CALCIUM HYPOCHLORITE, C

Although sodium hypochlorite (commercial liquid bleach) is sometimes used for this test, its high pH may theoretically result in a KC reaction (see 2.1.4). The original aqueous suspension of bleaching powder, calcium hypochlorite ($Ca(OCl)_2$), is thus preferable. The suspension has a short shelf-life, but was always found to be active when a chlorine odour was detectable. This was checked using a known positive such as *Parmotrema austrosinense* (Zahlbr.) Hale or *Parmelia subrudecta* Nyl.

A positive C reaction indicates a resorcinol, without resonance withdrawing (such as $-CHO$ and $-COOH$) or bulky (such as $-CH_2OOCCH{=}CHCOOH$) groups between the two hydroxyls. A positive C reaction is still obtained if groups such as $-CH_3$, $-Cl$ and to a lesser extent $-CH_2OH$ are between the two hydroxyls. The mechanism and cause of colour production is not known, but Santesson (1973) reported that the yellow tetrachlorodihydroorcinol was the only coloured compound isolated from the C reaction with orcinol.

In the present collection, the only compound to give a strong C reaction is lecanoric acid, but sometimes the concentration is so low that no reaction is obtained. This was observed for a specimen of *X. worcesteri* (772 4-2-16pp.) growing in total shade on the underside of a rock. Gyrophoric acid, which is often reported as C+ pink, is C- in the few examples available, and this is also presumed to be due to the low concentrations present. 4-O-demethylbarbatic acid gives a C+ yellow to orange reaction. Specimens containing either hypoprotocetraric or 4-O-demethylnotatic acids (depsidones lacking free meta hydroxyls) or both, give a pale citrine yellow reaction with C, which is sometimes also fleeting yellow to pale orange initially. Similar exceptions are known for glomellic and glomelliferic acids in the Neofusceliae (Esslinger, 1977).

2.1.4 POTASSIUM HYDROXIDE-CALCIUM HYPOCHLORITE, KC

For this test the K reagent is applied to the medulla first, followed immediately by the C reagent. Lichen substances which on hydrolysis with K, satisfy the conditions stipulated above for the C reaction, give a KC+ reaction. The would be KC+ colour responses are not observable with theoretically KC+ lichen substances which give colours with K.

In the Karoo Xanthoparmeliae the colours elicited by KC+ substances are rather weak, ranging from pale rose to orange. Although often weak, the KC reaction is very useful in the elimination of the possibilities of those lichen substances which do not otherwise react with any of the spot reagents.

2.2 MICROCRYSTAL TESTS (MCT)

The elucidation of the chemical structures of the lichen substances brought the realization that spot tests were insufficient to identify the lichen substances, and the microcrystal tests were developed (Asahina, 1936-1940). This relatively simple procedure facilitates the determination of many lichen substances, but many recrystallize unsatisfactorily, if at all, and mixtures can be a problem. In this study the microcrystal tests were used, where feasible, to confirm the identity of lichen substances previously identified by thin layer chromatography (TLC).

2.2.1 LICHEN SUBSTANCE EXTRACTION

A suitable quantity of cleaned lichen material is placed on a clean glass microscope slide and extracted several times with a suitable solvent (which is acetone in the majority of cases). It has been found that the most suitable method is to place the slide, raised about ½ mm at one end, on a slide warmer. The lichen material is placed on the lower end of the slide and flooded with the required solvent. Upon evaporation of the solvent, it is found that a large proportion of the residue crystallizes out on the raised end. Subsequent extractions using successively smaller amounts of solvent, results in a series of residue bands on the raised side of the slide.

Double extractions were needed for species such as *X.endomiltodes* and *X. ianthina*, because the pigments interfere with both the MCT and TLC. In this case the lichen material was extracted with benzene first and the residue collected, followed by the normal acetone extraction. It was found necessary to extract the acetone residue with benzene once again as it was slightly contaminated with pigments. The combined benzene residue was then treated *separately from* the acetone residue.

2.2.2 RECRYSTALLIZATION FROM STANDARD SOLVENTS

The acetone residue (*sometimes* with prior extraction with benzene, to remove ant[illegible]nones and fatty acids) is scraped together and distribu[illegible] clean, labelled microscope slides as the number of micro[illegible] requires. The *recrystallizing* solvents used are: (All proportions by volume, respectively.)

GAAn - glycerol:ethanol:aniline 2:2:1

GAoT - glycerol:ethanol:*o*-toluidine 2:2:1

GAQ - glycerol:ethanol:quinoline 2:2:1

GAW - glycerol:ethanol:water 1:1:1

GE - glycerol:glacial acetic acid 1:3

GWPy - glycerol:water:pyridine 1:3:1

Two to three drops of the required solvent are placed beside the residue, allowed to run *into it*, and covered with a glass coverslip. The slide is then warmed gently over a spirit flame or low bunsen burner, taking judicious care that the solvent does not boil, until the residue is largely or completely *dissolved* (*observed by the opacity* of the solution). The slide is then allowed to cool at room temperature, and observed under a compound microscope after ten minutes, two hours and 24 hours. The crystal formations are compared to those reported in *various sources*, such as Hale (1967b, 1969, 1979) and Taylor (1967, 1968), as well as many individual papers dealing with specific or specific groups of lichen substances. Hale (1967b) and Taylor (1967) give detailed well illustrated accounts of the microcrystal test procedure. Plates 9 to 13 depict microcrystals of some of the lichen substances found in the Karoo Xanthoparmeliae. The photomicrographs, plates 9C, 13C and D, show substances which were used for comparative purposes and were not present in *Xanthoparmelia* in the Karoo.

2.3 THIN LAYER CHROMATOGRAPHY (TLC)

A variety of chromatographic procedures for lichen substances have been published in the past, but these have each dealt with relatively small numbers of these compounds (see Santesson (1973)). Culberson and Kristinsson's (1970) publication however, presents a routine method for identifying many known and some unknown lichen substances. In the present study this method has been used together with the later modifications and improvements of C.F. Culberson (1972, 1974).

2.3.1 PLATE PREPARATION AND EXTRACT APPLICATION

Merck Silica gel $60F_{254}$ precoated TLC plates (layer thickness 0,25 mm) were used for the chromatographic analysis. 10 x 20 cm plates were used for economy, as most substances could be characterized adequately with a 7½ to 8 cm run. The method relies on the behaviour of the lichen substances on these plates in three different solvents, denoted A, B and C (see 2.3.3). Each plate can accommodate 15 lichen extracts applied as spots. Thus for each set of 15 lichen extracts to be analysed, three TLC plates are required, labelled A, B and C for the solvents they are to be run in. A line (the origin) is drawn in soft pencil, 2 cm from the bottom (20 cm margin) of each plate. This line in turn is divided up into 18 positions, 1 cm apart, leaving 1.5 cm free at both ends. It is also useful to clear ½ mm of the silica gel layer from around the periphery of the plate to prevent soiling of the layer during handling. Positions 1,9 and 18 are spotted with a standard mixture containing norstictic acid and atranorin. In this case the standard mixture consisted of the combined extracts of *Omphalodium hottentottum* (Ach.) Flot. and *Heterodermia boryi* (Fee) Hale.

Each of the 15 residues, obtained as described in section 2.2.1, is scraped into a corner of the slide, redissolved in one or two drops of acetone and taken up into a finely drawn out pasteur pipette. This is then applied to the identical position on the origin of each of the three plates. The above process is repeated until the residue is completely removed from the slide and spotted onto the plates. Each position is labelled suitably as the residue transfer is completed. The capillary pipettes are, of course, cleaned thoroughly with acetone before proceeding with the next residue.

2.3.2 EQUILIBRATION

Since the Merck company reduced the concentration of binder in their silica gel precoated plates, it has become necessary to equilibrate the spotted plates B and C in acidic atmospheres to retain, as far as possible, the R_f values published originally by Culbersen (1972) (Culberson, 1974). Plate B is equilibrated for 10 minutes over (but not in) 70% aqueous formic acid in a sealed glass vessel, and run immediately. Plate C is equilibrated over glacial acetic acid in the same way, and run immediately.

2.3.3 THE CHROMATOGRAPHIC RUN

The three solvent systems used are (by volume, respectively):

A	Benzene: dioxan: glacial acetic acid	180:45:5
B	Hexane: diethyl ether: formic acid	125:85:20
C	Toluene: glacial acetic acid	200:30

All solvents used were of analytical grade and were not purified further. The solvents are used at a depth of 1 cm in three standard TLC tanks respectively. In the present study it was necessary to use filter paper liners in the tanks containing solvents A and C, in order to adjust the R_f value of atranorin to a suitable value (0.7 to 0.8). The liner for solvent A was 8 cm in height above the solvent level, and that for solvent C was 2 cm in height. No liner was necessary for solvent B. The ambient temperature was also found to affect this, higher temperatures increasing the R_f value of atranorin. A suitable running temperature was 23°C, under the conditions stipulated above. After a ten minute vapour equilibration period for plates B and C, the plates are run in their respective solvents to a height of 7.5 to 8.0 cm. Immediately after removal, the positions of the solvent fronts are marked in soft pencil.

2.3.4 VIEWING AND DEVELOPMENT

The plates are viewed in daylight, and in longwave (λ max = 350 nm) and shortwave (λ max = 254 nm) ultraviolet light. The positions and optical characteristics of the spots were recorded on the plates themselves, using a marking code. They are then sprayed with 10% sulphuric acid (H_2SO_4) in an efficient hood. The plates are dried in an oven, till the free liquid just evaporates from the surface of the silica gel layer. At this point, aliphatic substances show up as unmarked opaque spots, and are encircled in a distinctive manner. The plates are heated at 110°C for 15 to 20 minutes to reveal the variously coloured spots of the aromatic and alicyclic lichen substances present. The reverse sides of the plates are then wiped dry to remove any remaining sulphuric acid.

The colours of the spots were recorded one or two days after development, but the colour on removal was also noted. In most cases the colours remained essentially the same, but barbatic and 4-O-demethylbarbatic acids, and the associated unknown compounds were exceptions.

The spots of these compounds were yellow but became ochre after 24 hours. This is in contrast with orcinol *para*-depsides such as divaricatic acid (which has similar R_f values to barbatic acid under the conditions used), which remain yellow at 24 hours.

2.3.5 DETERMINATION OF R_f CLASSES AND R_f VALUES

The R_f classes are based on the two control substances, norstictic acid and atranorin. The outer limits of the control substance spots at positions 1,9 and 18 are joined together by straight lines in soft pencil. The tops of the spots at the origin are joined in the same way. If the distance between the latter line and the lower norstictic acid line is divided into two, and the distance between the upper norstictic acid line and the lower atranorin line is treated likewise, then the plate is divided into 8 R_f classes (zones) as defined by Culberson and Kristinsson (1970). These R_f classes are numbered 1 to 8 as in figure 4.

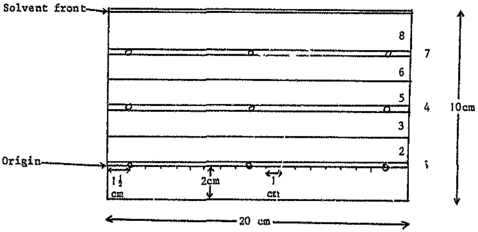


Fig. 4 DIAGRAM OF A TLC PLATE SHOWING R_f CLASSES (AFTER CULBERSON AND KRISTENSSON (1970)).

Although the R_f class combination and the optical characteristics of both developed and undeveloped lichen substance spots narrow down the number of possibilities considerably, it is usually necessary to determine the actual R_f values, if any meaningful comparisons to published results are to be undertaken. The R_f value of any spot is the distance that it has migrated, divided by the distance of the solvent front from the origin. The R_f value is always equal to, or less than one, but in the lichenological literature, it has become customary to eliminate the decimals by multiplying through by a factor of 100. The R_f value of any particular lichen substance is compared to published data, in the light of the R_f values of the control spots (norstictic acid and atranorin). These latter values conventionally follow the R_f value of each lichen substance, preceded by a virgule (/) (See Table 1). The R_f value of the boundary between R_f classes 5 and 6 is placed in parentheses in table 1, and is included for convenience. Thus in table 1, the R_f classes of each lichen substance are followed by three sets of figures: those preceding the virgule being the R_f values (x 100) of the lichen substance in the three solvent systems, and those following the virgule being the R_f values of the control substances, with the R_f value of the 5-6 R_f boundary in parentheses.

2.3.6 MICROHYDROLYSIS

This procedure was used to identify depsides with undiagnostic or ambiguous R_f values. Where necessary the compounds to be hydrolysed are separated by preparative layer chromatography using the most suitable of the three standard solvents. The bands of the separated depsides are located in short wave UV, and each scraped off into a separate small vial. The microhydrolysis was carried out with the depside on the silica gel, in these cases. A minimum amount of concentrated sulphuric acid (usually

3-6 drops, depending on the amount of residue) is added to the residue in a small glass vial and mixed thoroughly using a whirlymixer. The solution is cooled in a freezer for 15 minutes, and then crushed ice added, which is mixed into the solution. The dilute acid solution is extracted three successive times with ether, each drawn off with a pasteur pipette, and evaporated on a microscope slide. The residue is taken up in ether and spotted onto three TLC plates, next to spots of unhydrolysed material, in the usual manner. In this study the identity of evernic acid, the barbatic acid group and compounds related to thamnolic acid were established with the aid of microhydrolyses.

(i) Evernic acid was identified by microcrystal tests (plate 13E and F), and as the R_f values deviated from those published for this substance, confirmation of this identification was required. To this end barbatic, lecanoric, evernic and divaricatic (obtained from *Neofuscelia pulla* (Ach.) Essl., plate 9C) acids were run next to their hydrolysis products on the same plate. The results show the presence of orsellinic acid (ring B, the subunit of both rings of lecanoric acid) and 4-O-methyl orsellinic acid (running just below 2 hydroxy-,4-methoxy-6-propylbenzoic acid, the A ring of divaricatic acid) in evernic acid (Table 2).

(ii) The number of possibilities of compounds with similar R_f combinations to barbatic acid was relatively large, and a series of other compounds, including 4-O-demethylbarbatic acid, commonly occurred with it. Specimens of *X. brunnthaleri* containing large amounts of pairs of these substances were selected, and the lichen substances in each separated by preparative layer chromatography, using the most suitable solvent system. Barbatic and 4-O-demethylbarbatic acids and the unknowns barb-1 to barb-4 were run with baeomysic acid and atranorin, each next to its respective hydrolysis residue. Baeomysic acid was obtained from *Siphula torulosa* (Thunb. ex Ach.) Nyl.(772 6-1-14; see Bendz et al. (1965) and Mathey (1971)). All the β-orcinol depsides in *X.brunnthaleri*, except barb-4, contained 3-methylorsellinic acid (the B ring of baeomysic acid). None contained methyl 3-methylorsellinate (the B ring of atranorin). 4-O-demethylbarbatic acid is composed of 3-methylorsellinic acid alone, whereas barbatic acid has this and 4-O-methyl-3-methylorsellinic acid as subunits. Barb-2 yielded an unknown subunit (2, in table 2), pale pinkish-brown in colour on development. Second subunits for barb-1 and -3 were not detected, although both were distinct not only from each other, but also from 4-O-demethylbarbatic acid (Table 1).

(iii) The 3 [illegible] ity of baeomysic acid, is oxidised to a carboxyl (or carbino[illegible] roup in the concentrated sulphuric acid used in the microhydrolysis procedure. The oxidised A ring of baeom~~y~~cesic acid, 4-O-methyl-3-carboxyorsellinic acid, is identical to those of thamnolic acid, Th-1, and of course, squamatic acid. The other subunits, such as the 3-formyl-5-hydroxyorsellinic acid of thamnolic acid, are presumed to remain at the origin.

2.3.7 TABLES 1 AND 2

Table 1 lists the lichen substances found in the Karoo Xanthoparmeliae. The structures of all named compounds are known with the exception of connorstictic acid. Connorstictic acid and loxodin were included in the table for the sake of completeness although they were not detected in the present *Xanthoparmelia* collection. About half of the compounds are of unknown structure, but most species contain at least one compound of known structure. Several substances occurring sporadically in minor amounts were omitted from the table, because of the doubt surrounding their R_f characteristics.

TABLE I

LICHEN SUBSTANCE	R_f CLASS			R_f VALUE x 100			Visual Characteristics	Colour with H_2SO_4 treatment	UV CHARACTERISTICS	
	A	B	C	A	B	C			350 nm	254 nm
Q-1 (Unknown with hypoprotocetraric acid)	1	2-3	1	1/38,74(56)	16/33,67(49)	0/32,78(56)	-	Orange-brown	Pale	Quench
Fumarprotocetraric acid	1	3	2	0/38,74(55)	29/34,70(52)	9/32,79(55)	-	Carbonizes	-	Quench
Protocetraric acid	1-2	3	2	4/37,73(55)	23/34,70(51)	5/31,78(54)	-	Carbonizes	-	Quench
Tha-3 (associated with Th-1)		1	1	10/37,74(55)	0/39,73(53)	?/32,74(52)	-	-	White	-
Tha-2 (associated with Th-1)	2	1	1	16/37,74(55)	0/39,73(53)	?/32,74(52)	-	-	White	-
Brun-3 (Always in trace amounts)	2	1	1-2	13/36,72(53)	0/32,67(48)	3/31,69(50)	-	Pale yellowish	-	Quench
Consticic (4-0-methylsalazinic) acid	2	1-2	1	5/36,74(54)	2/36,72(53)	1/30,82(56)	-	Brown	-	Quench
Connorstictic acid	2	2	1-2	9/36,74(54)	11/33,70(51)	3/33,79(56)	-	Orange	-	Quench
Salazinic acid	2	2	2	9/36,73(54)	8/36,71(53)	3/30,81(56)	-	Brown	-	Quench
PQ-4	2	2	2	11/35,72(54)	7/31,69(51)	3/33,78(55)	-	Brick-red or reddish-brown	-	Quench
Succinoprotocetraric acid	2	3	2	7/38,74(55)	21/36,72(53)	11/34,81(57)	-	Carbonizes	-	Quench
FB-2	2	3	2	8/41,75(57)	22/30,68(48)	9/34,78(56)	-	Pinky-brown	White or pale	Quench
Thamnolic acid	2	3	2-3	8/39,76(57)	21/34,73(53)	16/34,77(55)	-	Pinky-brown	Pale or -	Quench
Squamatic acid	2	3-4	3	13/40,75(56)	32/34,73(53)	26/34,77(55)	-	Salmon-brown	White	Quench
Physodalic acid	2	4-5	3	13/38,74(55)	39/36,72(53)	20/34,81(57)	-	Carbonizes	-	Quench
FB-1	2	4-5	3-4	16/41,75(57)	32/30,68(48)	30/34,78(56)	-	Pinky-brown	White or pale	Quench
2'-0-demethylpsoromic acid	2	5	2	15/40,73(56)	40/33,76(53)	14/34,78(56)	-	Greenish or greenish-grey	-	Quench
Subd-5	2-3	1	2	18/34,72(52)	?/26,63(45)	15/32,74(53)	-	- or pale	-	-
Subd-4	2-3	1	3	18/34,72(52)	?/26,63(45)	21/32,74(53)	-	- or pale	-	-

TABLE I (Continued)

LICHEN SUBSTANCE	R_f CLASS			R_f VALUE x 100			Visual Characteristics	Colour with H_2SO_4 treatment	UV CHARACTERISTICS	
	A	B	C	A	B	C			350 nm	254 nm
"Chalybaeizans unknown"	2-3	2	2	15/36,73(54)	10/35,71(53)	11/29,81(56)	-	Greyish-brown	White or pale	Quench
4-0-demethylnotatic acid	2-3	5	2-3	19/37,71(53)	38/34,71(52)	14/29,78(54)	-	Brown	White or pale	Quench
Th-2	3	1	1-2	21/35,72(54)	20/35,65(49)	6/32,77(54)	-	Olive green or greyish	Brown	Quench
Brun-2	3	1	2	28/36,72(53)	0/32,67(48)	8/31,69(50)	-	Pale olive green	-	Quench
Sch-2	3	1	2-3	29/36,70(52)	20/34,70(51)	16/32,82(57)	Orangy-green	Grey	Dark	Quench
Stictic acid	3	2	2-3	23/36,74(54)	9/36,72(53)	14/30,82(56)	-	Red-brown	-	Quench
Hyposalazinic (4-0-demethylhypostictic)	3	3	2	23/35,72(54)	27/31,69(51)	8/33,78(55)	-	Orange, sometimes carbonizing slightly	-	Quench
Barb-4	3	3	3	29/37,75(56)	28/34,70(52)	22/32,78(55)	-	Brown	-	Quench
Subd-1 (PP-2)	3	4	4	27/34,72(52)	27/26,63(45)	31/32,74(57)	-	- or pale	-	-
Hypoprotocetraric acid	3	5	3	23/37,71(53)	43/34.71(52)	21/29,78(54)	-	Brown (with a salmon tinge)	White or pale	Quench
Lecanoric acid	3	5	3	26/39,77(57)	45/34,73(53)	27/36,84(60)	-	Yellow-orange, sometimes grey rimmed	Pale or -	Quench
Gyrophoric acid	3	5	3-4	32/41,80(61)	39/32,69(49)	28/32,76(55)	-	Yellow-orange	Pale or -	Quench
Notatic acid	3	5	5	26/37,71(53)	45/34,71(52)	44/29,78(54)	-	Brown	(-)	Quench
Virensic acid	3	5-6	5	25/37,73(55)	51/34,70(51)	45/31,78(54)	-	Carbonizes	-	Quench
St-1 (unknown with stictic acid)	3-4	3	3	34/36,74(54)	22/36,72(53)	25/30,82(56)	-	Orange	-	Quench
Barb-2	3-4	5	4	31/36,75(56)	46/38,71(53)	35/33,78(56)	-	Yellow becoming ochre	Pale or white	Quench
Subd-2 (PP-1)	3-4	5	5	32/34,72(52)	30/26,63(45)	37/32,74(53)	-	Pale grey-brow	-	-

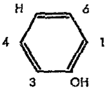
TABLE 1 (Continued)

LICHEN SUBSTANCE	R_f CLASS A	R_f CLASS B	R_f CLASS C	R_f VALUE × 100 A	R_f VALUE × 100 B	R_f VALUE × 100 C	Visual Characteristics	Colour with H_2SO_4 treatment	UV CHARACTERISTICS 350 nm	UV CHARACTERISTICS 254 nm
Psoromic acid	3-4	5	5	37/40,73(56)	44/33,76(53)	51/34,78(56)	-	Olive-grey to brown-grey	-	Quench
4-O-demethylbarbatric acid	3-4	5	5	36/38,74(55)	44/29,68(48)	40/31,80(55)	-	Yellow, becoming ochre	Pale	Quench
Evernic acid	3-4	5-6	5-6	36/39,77(57)	53/34,73(53)	63/36,84(60)	-	Yellow-orange, sometimes with grey rims	Pale or -	Quench
4-O-methylhypoprotocetraric acid	3-4	5-6	5-6	36/37,71(53)	49/34,71(52)	55/29,76(54)	-	Pinky-brown	Pale or white	Quench
Th-1	4	1-2	3	40/40,75(56)	6/39,73(56)	18/34,77(55)	-	Olive or brownish	Ochre or brown	Quench
Norstictic acid	4	4	4	-	-	-	-	Orange-red	-	Quench
Skyrin	4	4-5	3	36/36,76(55)	38/34,70(52)	23/32,73(53)	Yellow-orange	Carbonizes	Brown	Quench
Subd-6	4	5	5	35/34,72(52)	32/26,63(45)	41/32,74(53)	-		-	Quench
Subd-3	4	5	5	35/34,72(52)	34/26,63(45)	45/32,74(53)	-	Pale grey	-	Quench
'G-1	4	5	5	35/36,73(53)	43/28,68(46)	45/30,79(54)	-		-	-
Barb-3	4	5	5-6	37/37,75(56)	48/34,70(52)	58/32,78(55)	-	Yellow becoming ochre	Pale or -	Quench
Hypostictic acid	4-5	4	4-5	38/36,74(54)	37/36,72(53)	34/30,82(56)	-	Red sometimes carbonizing slightly	-	Quench
Barb-1	4-5	5-6	6	41/36,75(56)	55/38,71(53)	63/33,78(56)	-	Yellow becoming ochre	Pale	Quench
Barbatic acid	4-5	6	6	42/38,74(55)	52/29,68(48)	63/31,80(55)	-	Yellow becoming ochre	Pale	Quench
Brun-1	5	1	3-4	50/36,72(53)	0/32,67(48)	28/31,69(50)	-	Pale greenish -ochre	-	Quench

TABLE 1 (Continued)

LICHEN SUBSTANCE	R_f CLASS			R_f VALUE × 100			Visual Characteristics	Colour with H_2SO_4 treatment	UV CHARACTERISTICS	
	A	B	C	A	B	C			350 nm	254 nm
Endo-1	5	2-3	3-4	42/38,74(56)	16/32,67(48)	25/30,78(54)	Violet	Violet carbonizing slightly	Orange or red	(Quench)
Sch-1	5	2-3	5-6	42/36,70(52)	15/34,70(51)	56/32,82(57)	Greenish	Olive green	Strong yellow	Quench
Endo-4	5	3	4-5	46/38,74(56)	24/32,67(49)	33/30,78(54)	Violet	Violet	Violet or red	(Quench)
XG-2	5	4	5-6	42/36,73(53)	31/28,68(46)	56/30,79(54)	-	-	-	Quench
Norlobaridone	5	5	3	42/35,7[illegible]5)	41/34,71(53)	21/34,80(56)	-	Ochre	-	Quench
Tha-1 (associated with TH-1)	5	5	3	46/37,[illegible]	46/39,73(53)	18/32,74(52)	-	-	Pale	-
Loxodin (Methyl 4-0-demethylliobarate)	5	5	5	49/3[illegible],74([illegible])	43/34,71(53)	42/34,80(56)	-	Ochre	-	Quench
Endo-3	5-6	2	5-6	55/38,74(56)	7/32,67(48)	54/30,78(54)	Violet or red	Violet	Ora[illegible] to red	(Quench)
Endo-2	6	5	6	64/38,74(56)	42/32,67(48)	71/30,78(54)	Violet	Violet	Violet or red	(Quench)
Usnic acid	6	6	6	69/37,73(55)	62/34,70(51)	71/31,78(54)	Yellow	Carbonizes	Dark	Quench
Atranorin	7	7	7	-	-	-	-	Yellow-orange	-	Quench

TABLE 2. HYDROLYSIS DATA

Hydrolysis Product Number	HYDROLYSIS PRODUCT NAME	R_f CLASS							Example of R_fx100/ R_fx100 of norstictic acid, R_fx100 of atranorin (average of R_fx100 of both atranorin and norstictic acid)			Spot colour after H_2SO_4 treatment (Development)
		A	B	C	1	3	4	6	A	B	C	
1	4-0-Methyl-3-carboxyorsellinic acid	1-2,	2,	2	COOH	COOH	OCH_3	CH_3	3/52, 87(69)	15/43, 79(61)	7/27, 72(50)	Orange
2	Unknown	3,	5,	3-4	-	-	-	-	47/52, 88(70)	47/42, 78(60)	31/33, 84(59)	Pale pinkish brown
3	Orsellinic acid	4,	5,	4	COOH	H	OH	CH_3	50/52, 87(70)	52/43, 79(61)	33/33, 84(59)	Yellow to orange
4	2,4-Dihydroxy-6-n-propylbenzoic acid	4,	5-6,	5	COOH	H	OH	C_3H_5	53/52, 89(70)	59/42, 80(61)	45/35, 86(61)	Yellow to orange
5	3 Methylorsellinic acid	4-5,	5-6,	5	COOH	CH_3	OH	CH_3	54/52, 87(69)	58/42, 79(60)	48/34, 85(60)	Yellow becoming ochre
6	4-O-Methylorsellinic acid	5,	6,	6	COOH	H	OCH_3	CH_3	64/52, 87(70)	67/43, 79(61)	67/33, 84(59)	Yellow

7/ . . .

TABLE 2. HYDROLYSIS DATA (Continued)

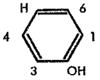
Hydrolysis Product Number	HYDROLYSIS PRODUCT NAME	R_f CLASS							Example of R_fx100/ R_fx100 of norstictic acid, R_fx100 of atranorin (average of R_fx100 of both atranorin and norstictic acid)			Spot colour after H_2SO_4 treatment (Development)
		A	B	C	1	3	4	6	A	B	C	
7	4-0-Methyl-3-methylorsellinic acid	5,	6-7,	6	COOH	CH_3	OCH_3	CH_3	64/52, 87(69)	74/42, 79(60)	73/34, 85(60)	Pinkish yellow becoming pinkish ochr
8	2-Hydroxy-4-methoxy-6-n propylbenzoic acid	5,	6-7,	6	COOH	H	OCH_3	C_3H_5	68/52, 89(70)	76/42, 80(61)	74/35, 86(61)	Yellow
9	Methyl 3-methylorsellinate	6,	6,	5	$COOCH_3$	CH_3	OH	CH_3	71/52, 86(69)	70/44, 81(62)	52/27, 88(54)	Yellow becoming ochre

Table 2 represents the hydrolysis data of this study, and one unknown is present (2).

2.4 THE CLASSIFICATION OF DEPSIDES AND DEPSIDONES

The classification of depsides and depsidones has been based on the most likely biosynthetic route (see section 2.6), that is, their formation from two to four orsellinic acid derivatives and/or analogues. Depsides and depsidones consisting of orsellinic acid (fig. 5) or related compounds, are called orcinol depsides and depsidones, and those derived from 3-methylorsellinic acid (fig. 6) or related compounds, are known as β-orcinol depsides and depsidones.

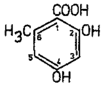


Fig. 5 Orsellinic acid

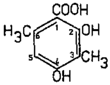


Fig. 6 3-methylorsellinic acid

The ring with a carboxyl group esterified with a phenol, is called the A ring, with positions o benzene ring labelled 1 to 6 as in figures 5 and 6. The remaining ring is known as the B ring, with aromatic positions labelled 1' to 6' in the same manner (Fig. 7).

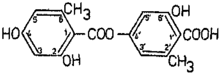


Fig. 7 The orcinol *para*-depside, lecanoric acid.

All known depsidones are esterified using the 4' hydroxyl group. *meta*-Depsides are derived from 2,4-hydroxy-6-methylbenzoic acid derivatives which possess "extra" aryl hydroxyls. In the orcinol *meta*-depsides the extra aryl hydroxyls occur in the 3' positions (fig. 8) whereas those in the β-orcinol *meta*-depsides occur in the 5' position (fig. 9). In both cases it is these "extra" hydroxyls that are esterified, so that the carboxyl group (if present) on the B ring is positioned *meta* to the ester functional group.

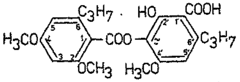


Fig. 8 The orcinol *meta*-depside, 2-O-methylsekikeic acid (Chester and Elix, 1978).

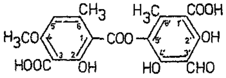


Fig. 9 The β-orcinol *meta*-depside, thamnolic acid.

The depsides and depsidones of the orcinol series are similar to one another in that they may contain: (a) n-alkyl groups containing up to 7 carbon atoms, in the 6 positions of the component 2,4-dihydroxybenzoic acid subunits; and (b) "extra" hydroxyl groups in the 3 positions of the subunits. The β-orcinol depsides and depsidones: (a) all possess "extra" single carbons in the 3 positions; (b) all have one carbon substituents in the 6 positions; and (c) may be hydroxylated in the 5 positions of the 2,4 dihydroxybenzoic acid subunits. There are a few examples of mixed depsides and depsidones, in which one ring is an orsellinic acid derivative, and the other a 3-methylorsellinic acid derivative. Such examples are restricted to the *para* esterification mode (i.e. no "extra" hydroxyls present,) and simple methyl substituents in the 6, and when present, 3 positions. (e.g. methyl 3'-methyllecanorate, 3'-methylevernic acid (Nicollier et al., 1979), obtusatic acid (fig. 10) norobtusatic, notatic (fig. 11), and 4-O-demethylnotatic acids).

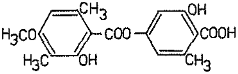


Fig. 10 The mixed depside, obtusatic acid.

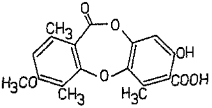


Fig. 11 The mixed depsidone, notatic acid.

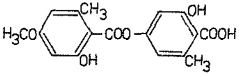
2.5 THE LICHEN SUBSTANCES

References to pertinent literature on the following compounds may *be found in Culberson* (1969a), Culberson (1970), and Culberson, Culberson and Johnson (1977). Only references not mentioned in these compendia will be cited.

2.5.1 ORCINOL DEPSIDES AND TRIDEPSIDES

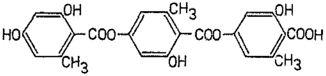
Only *para* lichen substances of this class are known in the Karoo Xanthoparmeliae.

(i) Evernic acid (4-O-methyllecanoric acid)



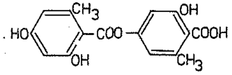
This is a rare substance in the Karoo Xanthoparmeliae occurring in a total of 5 specimens of two widely differing species, *X. heterodoxa* & *X.dysprosa*. Evernic acid occurs on the western and southern margins. All spot tests are negative except for an occasional KC+ rose or pale orange reaction. It recrystallizes as branched needle clusters in GE (plate 13E and F), and forms very coarse solid needles in GWPy and rectangular plate clusters in GAQ.

(ii)Gyrophoric acid



Gyrophoric acid is very rare in the Karoo Xanthoparmeliae, occurring on the southern margin in two specimens of the same species, *X.leucostigma*. It was not found as an accessory substance in any other species. Gyrophoric acid reacts C-, KC+ rose in the concentrations found, and reports indicate that it does not have a diagnostic microcrystal habit in any of the regularly used recrystallizing solvents.

(iii) Lecanoric acid

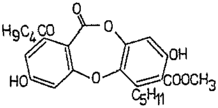


This substance is quite common in *Xanthoparmelia* occurring in 50 specimens of a common and a rare species, *X. worcesteri* & *X. heterodoxa* (in which it occurs as an accessory to evernic acid) respectively. Like *X. worcesteri*, lecanoric acid is widespread in the Karoo, and usually causes a strong C+ red reaction (K-P-). However, a specimen found on the underside of a rock (772 4-2-16) was C- due to the very low medullary concentration of this substance. Branched needle clusters in GAW (plate 10C) are typical for lecanoric acid.

2.5.2 ORCINOL DEPSIDONES

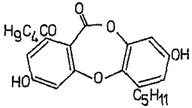
This class of lichen substances is rare in the Karoo Xanthoparmeliae, being represented by norlobaridone in two specimens of *X. scabrosa* from the northern Karoo.

(i) Loxodin (Methyl, 4-O-demethyllobarate; = Neoloxodic acid).



Loxodin occurs with norlobaridone, but in the Karoo specimens this substance was present in trace amounts.

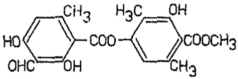
(ii) Norlobaridone (= loxodic acid)



As mentioned above, norlobaridone is rare in the Karoo, and is negative to all the spot tests except KC, which gives a rose colour. Microcrystal tests involving this substance were not performed. Norlobaridone is very common in the Australasian Xanthoparmeliae (Kurokawa, 1969; Hale, 1971; Galloway, 1979). Traces of other substances were also present, but the R_f values could not be correlated to those of the newly reported substances norlobariol (Foo and Gwyn, 1978), conorlobaridone and conloxodin (Beg et al., 1979). Loxodinol has also been reported recently for this species in New Zealand (Foo and Galloway, 1979).

2.5.3 <u>β-ORCINOL *para*-DEPSIDES</u>

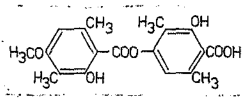
(i) Atranorin



[The depsidone corresponding to atranorin, is methyl virensate (Renner et al., 1978); = granulatin (Goh and Wilkens, 1979). The depsidone corresponding to 5-chloroatranorin is physciosporin (Maass et al., 1977),; =5-chloro-methylvirensate (Renner et al., 1978); = chlorogranulatin (Goh and Wilkins, 1979)].

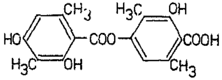
Atranorin is a common substance in lichens, but is rare in the Xanthoparmeliae. It occurs with usnic acid in trace to quite large amounts in several species, notably *X. chalybaeizans*, *X. leptoplaca* and *X.adhaerens*, and is therefore widespread within this genus in the Karoo. Clusters of long needles in GAoT (plate 10F). confirms the presence of atranorin.

(ii) Barbatic acid



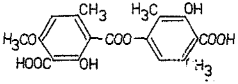
[The depsidone corresponding to barbatic acid is 4-O-methylhypoprotocetraric acid]. Barbatic acid is found in part of *X.brunnthaleri* and in the rare *X. burmeisteri*. It was found in about 24 specimens, often together with 4-O-demethylbarbatic acid. In *X. brunnthaleri* these two substances occur with barb-1 to barb-4, with various combinations of 2 to 4 of these 6 substances per individual. This substance is widespread, but like its main producer, *X. brunnthaleri*, is abundant in the central and eastern areas of the Karoo. The only spot test to give a positive colour reaction with barbatic acid is the KC test, which gives a rose to pale orange colour. This substance recrystallizes from GAoT as thin plate clusters (plate 9A and B, and possibly plate 10A), and as coarse cubes or square rods from GE (plate 10B).

(iii) 4-O-demethylbarbatic acid



[The depsidone corresponding to 4-O-demethylbarbatic acid is hypoprotocetraric acid]. This depside occurs with the 4-O-methylated derivative, barbatic acid, or with the unknowns barb-1 to -4, in about 17 specimens of the same two species mentioned under barbatic acid. 4-O-demethylbarbatic acid is distributed similarly to barbatic acid, and appears to be the cause of the C+ citrine yellow to orange reaction. The KC reaction is always stronger when a C+ reaction is present, becoming bright orange in some cases.

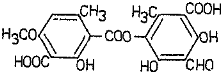
(iv) Squamatic acid



Squamatic acid is rare in the Xanthoparmeliae of the Karoo occurring at Pakhuis Pass near Clanwilliam in 3 specimens of the two unrelated species *X. hypomelaena* and *X. squamatica*. Squamatic acid is very strongly blue-white fluorescent in longwave UV, which distinguishes it from any other known compound in this genus. It does not react with any of the spot reagents, although, like atranorin, a KC+ response is expected in theory. This substance forms coarse prisms in GAAn (plate 13A).

2.5.4 β-ORCINOL *meta*-DEPSIDES

(i) Thamnolic acid

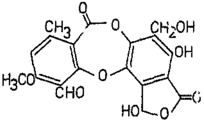


Thamnolic acid was found in two specimens of the type strain of *X. hypomelaena*, which occurs on the southern and southwestern margins. Thamnolic acid reacts with K to give a colour which is rich citrine yellow at first, which then becomes yellow-orange. It gives an orange colour with P, but is negative with the KC and C spot reagents. Dissolving thamnolic acid in concentrated sulphuric acid for microhydrolysis results in effervescence,due to the decarboxylation of the 1' carboxyl group. This substance gives large branched clusters of small needles in GAAn (plate 9D).

2.5.5 β-ORCINOL DEPSIDONES

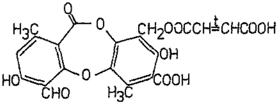
These are the most frequent compounds found in the Karoo Xanthoparmeliae.

(i) Constictic acid (4-O-methylsalazinic acid)



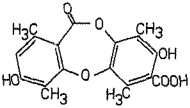
Conscictic acid occurs consistently with stictic acid (never with salazinic acid), in moderate, or less commonly major amounts. See section 2.5.5 (xiv) for the distribution of this substance

(ii) Fumarprotocetraric acid



This substance is widespread but not common in the Karoo Xanthoparmeliae, and was identified in 7 specimens of *X. subconspersa*. Fumarprotocetraric acid was always found with either succinoprotocetraric or protocetraric acids or both. The K reagent gives no colour at first but then develops a dingy yellow to dingy red colour. Fumarprotocetraric acid reacts with Steiner's stable P reagent to give a yellow colour which becomes a blood red colour over a minute or so.

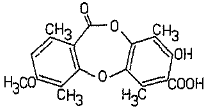
(iii) Hypoprotocetraric acid



[The depside corresponding to hypoprotocetraric acid is 4-O-demethylbarbatic acid.]

Hypoprotocetraric acid was found usually in major amounts, rarely in small amounts, in about 140 specimens of *X. perspersa*, 15 specimens of *X. hypoprotocetrarica*, and 8 specimens of *X. columnata*. This substance is extremely common and widespread, becoming rare only in the Northern Karoo. Hypoprotocetraric acid is (a) K+ faint yellow, sometimes becoming wine rose to pale violet on drying; (b) often KC+ rose; and (c) P–. Medullae containing this compound are also often a faint rose colour, which turns to a very pale citrine yellow colour on application of C. As reported by Culberson (1965), hypoprotocetraric acid recrystallizes from GE as fine to coarse prisms (plate 11D and E) and as gently sickled elongate plates from GWPy (plate 11A, B, and C).

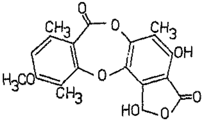
(iv) 4-O-methylhypoprotocetraric acid



[The depside corresponding to 4-O-methylhypoprotocetraric acid is barbatic acid.]

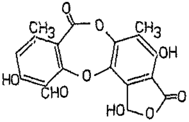
Although the R_f values obtained for this compound differ from those reported by Culberson and Hale (1973), it is assumed to be due to the change in the binder concentration in the silica gel of the TLC plates used (see section 2.3.2). It was found in subsidiary amounts in 14 out of 15 specimens of *X. hypoprotocetrarica*, 7 specimens of *X. columnata*, and 24 (mostly subcrustose) out of 150 specimens of *X. perspersa*. The geographic distribution of 4-O-methylhypoprotocetraric acid is essentially that of hypoprotocetraric acid except that it occurs more rarely.

(v) Hypostictic acid



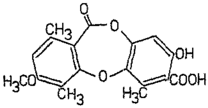
Hypostictic acid, which has been known as PQ-1 (Culberson, 1972), was first found in *X. quintaria* (Hale) Hale (Hale, 1971), a taxon not present in the Karoo collections. The structure of this despidone was elucidated by Keogh (1978) and was encountered sporadically (on three occasions) with stictic acid in *X. adhaerens*. Hypostictic acid is conspicuous on developed TLC plates as bright red spots, which are in contrast to those of norstictic acid, which are orange.

(vi) Norstictic acid (4-O-demethylstictic acid)



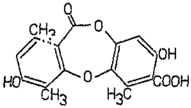
Norstictic acid is widespread as a subsidiary compound in species containing salazinic or stictic acids. The spot tests are obscured by those of the accompaning substances, but loose, staggered or clustered square plates in GAoT are diagnostic for norstictic acid (plate 12C, D, E, and F).

(vii) Notatic acid



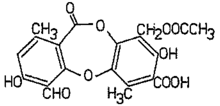
[The depside corresponding to notatic acid is obtusatic acid.] Notatic acid was found occasionally in *X. persperea*, in trace to minor amounts. The substance is easily detected on plate C, where it is clearly separated from hypoprotocetraric and 4-O-demethylnotatic acids, and associates.

(viii) 4-O-Demethylnotatic acid



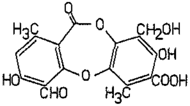
[The depside corresponding to this depsidone is norobtusatic acid.] Unlike notatic acid, its 4-O-demethyl derivative is both common and widespread (in *X. perspersa*) in the Karoo. It was absent, or present only in trace amounts in all specimens of *X. hypoprotocetrarica* and *X. columnata* in this collection, but Culberson and Hale (1973) reported it present in the latter species. 4-O-demethylnotatic acid was present in minor to frequently major amounts, in most (120 out of 150) specimens of *X. perspersa*. This substance is presumed to be responsible for the rose to orange KC reaction, which is slightly stronger than that produced by hypoprotocetraric acid.

(ix) Physodalic acid ("acetoprotocetraric acid")



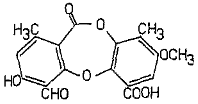
Physodalic acid occurs fairly frequently in trace to minor amounts with fumar- and succinoprotocetraric acids in *X. subconspersa*. The response to the spot reagents is masked by the more abundant compounds with which it occurs. Microcrystal tests were not attempted because of the low amounts present in relation to other substances, but it crystallizes from GE as colourless elongate prisms (Kurokawa, 1967).

(x) Protocetraric acid



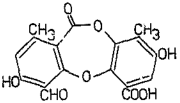
Protocetraric acid, present in *X. dichromatica* (30 specimens), *X. hypoleia* (30), *X. schenckiana* (75) and *X. subconspersa* (45), is very common and widespread in the Karoo, occurring in 1/5 of the collection. Protocetraric acid reacts K- or faint yellow, KC+ rose, C-, and P+ orange to orange-red. It is found consistently with virensic acid in *X. hypoleia*, and is often present in *X. subconspersa*, alone or in variable combinations, with multiples of up to three of succinoprotocetraric, physodalic, fumarprotocetraric and virensic acids.

(xi) Psoromic acid



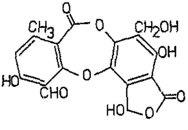
Psoromic acid is present in *X. psoromifera*, which is widespread in the Karoo, but abundant only in the Northern Karoo (26 specimens examined). The specimens (which contain 2'-O-demethylpsoromic acid also) are all P+ citrine- to golden-yellow, but negative to the remaining spot reagents. Although identical to the psoromic acid in *Rhizocarpon geographicum* (L) DC in TLC characteristics and spot reactions, the psoromic acid from *X. psoromifera* failed to crystallize in GE. (Plate 13C, and D show psoromic acid from *R. geographicum* (768 10-2-8) recrystallized from GE.)

(*xii*) 2'-O-demethylpsoromic acid (= conpsoromic acid; = neopsoromic acid)



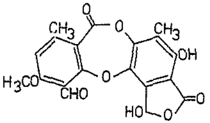
Evidence for the structure of this compound was presented by Keogh (1976). 2'-O-demethylpsoromic acid occurs consistently with psoromic acid in *X. psoromifera*, but usually in lesser amounts.

(xiii) Salazinic acid



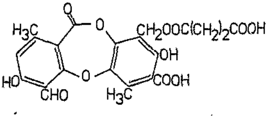
Salazinic acid is very common and widespread in the Karoo, occurring in several species of *Xanthoparmelia*, some of which are very abundant. These are *X. chalybaeizans* (135 specimens), *X. colorata* (25), *X. constrictans* p.p. (15), *X. endomiltodes*(5), *X. exornata* (50), *X. hyporhytida* (2), *X. leptoplaca* (50), *X. tasmanica* (35). Salazinic acid is present in approximately one third (320 specimens) of the collection. This substances gives a yellow colour on initial application of K, which becomes blood-red within a minute. The KC test may bleach the K response, and C alone has no effect. An orange colour is produced with P. Salazinic acid forms boat shaped crystals in GAoT (plate 10D).

(xiv) Stictic acid



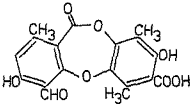
Stictic acid, in contrast to salazinic acid, is uncommon in the Karoo, occurring along the southern and western margins in *X. adhaerens* (15 specimens, *X. conspersa* (1), *X. constrictans* p.p. (20), and *X. molliuscula* (6). The K test gives a yellow or yellow-orange colour and the P test gives an orange colour with stictic acid. However these colours are the combined effects of stictic and constictic acids, and other β-orcinol depsidones occurring with them, on these reagents. Stictic acid forms unmistakeable hexagonal plates in GAoT (plate 12A, and B).

(xv) Succinoprotocetraric acid (= sublimbatic acid)



Succinoprotocetraric acid is common in the widespread species *X. subconspersa* (50 out of 75 specimens) and present in *X. subramigera* (2 out of 2). This compound doesn't react with K at first, but slowly becomes a dingy orange or red over a period of a few minutes. The KC test may bleach the K reaction and the C test itself is negative. Succinoprotocetraric acid reacts with Steiner's P reagent to give a yellow colour which becomes blood-red within a minute.

(xvi) Virensic acid

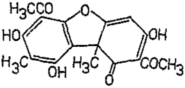


Virensic acid is found consistently with protocetraric acid in *X. hypoleia* (30 specimens). It is also found in *X. subconspersa* as an accessory (10 specimens).

2.5.6 USNIC ACIDS

In the present study, the determination of the stereochemistry of usnic acid in the various species was not attempted.

(i) Usnic acid

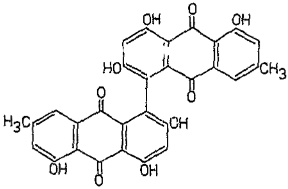


Usnic acid is present in all the *Xanthoparmeliae*, and localized in the upper 10-30 µm of the upper cortex. It is negative to all the usual spot tests, but crystallizes from GE as coarse yellow needles, which may be flag-tipped (plate 10E).

2.5.7 ANTHRAQUINONES

Of the several anthraquinoid pigments in the *Xanthoparmeliae* from the Karoo, only one is a known anthraquinone.

(i) Skyrin (= rhodophyscin)



This bisanthraquinone is known from *X. chalybaeizans*, *X. persperea* (where it is especially common in foliose forms with pale lower surfaces), and *X. subconsperea*. It occurs in trace to major amounts in the medulla adjacent to the lower cortex, usually in the central (older) portions of the thallus. Skyrin is yellow-orangish in colour and becomes violet on application of K. The pigment can be missed easily as TLC is normally carried out on the extracts from terminal lobes.

2.5.8 UNIDENTIFIED AND UNKNOWN SUBSTANCES

(i) Suspected β-orcinol Depsides

(a) Barb-1, barb-2, barb-3, and barb-4

These substances occur in part of *X. brunnthaleri* with or without barbatic and/or 4-O-demethylbarbatic acids. Both barb-1 and barb-2 occurred in 30 out of 55 specimens containing this range of substances, often but not always together. Barb-3 and barb-4 were found together with barb-2 in three specimens from Gapkop, west of Victoria West. The evidence presented in section 2.3.6 (ii) leads one to suspect that barb-1, -2 and -3 are β-orcinol *para*-depsides. Barb-4, however, failed to hydrolyse and may be a depsidone. The brown colour of the barb-4 spot (as opposed to the ochre colours of the others) on developed TLC plates, is also significant (Culberson and Kristinsson, 1970). None of these unknowns match the β-orcinol depsides reported for *Oropogon loxensis* (Fee) Th.Fr. (Culberson and Culberson, 1978) and *Xanthoparmelia moctezumensis* Nash (Culberson, Nash and Johnson, 1979).

(b) Th-1 and Th-2

Th-1 is found alone in *X. hypomelaena* p.p. and with Th-2 in *X. ianthina*. Both of these taxa are represented by a handful of specimens from the western margin of the study area. The respective taxa on the southern margin contain thamnolic acid (*X. hypomelaena* p.p.) and salazinic acid (*X. endomiltodes*). As explained in section 2.3.6 (iii), Th-1 contains the A-ring (4-O-methyl-3-carboxyorsellinic acid) of thamnolic and squamatic (= oxidized baeomysic) acids. However the B-ring, like that of thamnolic acid, remained undetected and is presumed to have remained at the origin of each of the TLC plates.

2.5.8 UNIDENTIFIED AND UNKNOWN SUBSTANCES

(i) Suspected β-orcinol Depsides

(a) Barb-1, barb-2, barb-3, and barb-4

These substances occur in part of *X. brunnthaleri* with or without barbatic and/or 4-O-demethylbarbatic acids. Both barb-1 and barb-2 occurred in 30 out of 55 specimens containing this range of substances, often but not always together. Barb-3 and barb-4 were found together with barb-2 in three specimens from Gapkop, west of Victoria West. The evidence presented in section 2.3.6 (ii) leads one to suspect that barb-1, -2 and -3 are β-orcinol *para*-depsides. Barb-4, however, failed to hydrolyse and may be a depsidone. The brown colour of the barb-4 spot (as opposed to the ochre colours of the others) on developed TLC plates, is also significant (Culberson and Kristinsson, 1970). None of these unknowns match the β-orcinol depsides reported for *Oropogon loxensis* (Fee) Th.Fr. (Culberson and Culberson, 1978) and *Xanthoparmelia moctezumensis* Nash (Culberson, Nash and Johnson, 1979).

(b) Th-1 and Th-2

Th-1 is found alone in *X. hypomelaena* p.p. and with Th-2 in *X. ianthina*. Both of these taxa are represented by a handful of specimens from the western margin of the study area. The respective taxa on the southern margin contain thamnolic acid (*X. hypomelaena* p.p.) and salazinic acid (*X. endomiltodes*). As explained in section 2.3.6 (iii), Th-1 contains the A-ring (4-O-methyl-3-carboxyorsellinic acid) of thamnolic and squamatic (= oxidized baeomysic) acids. However the B-ring, like that of thamnolic acid, remained undetected and is presumed to have remained at the origin of each of the TLC plates.

Th-1 gives a yellow colour at first, but rapidly becomes bright orange to bright orange-red with K. It gives an orange colour with P, and is C- and KC-. The *o*-toluidine adduct of Th-1 crystallizes as branched needle clusters from GAoT (plate 13B). Th-1 is yellow brown or brown in longwave UV and is olive to brownish on developed TLC plates, whereas Th-2 is brown in longwave UV and is olive-green to greyish on these plates. Although not studied further, Th-2 appears similar to Th-1. All the evidence indicates that Th-1 is a β-orcinol *meta*-depside.

(ii) Suspected β-Orcinol Depsidones

(a) FB-1 and FB-2

These two unknowns occur with a compound assigned tentatively to 4-O-methylhypoprotocetraric acid, in a single specimen (772 14-2-4) which was relegated to *X. parsparsa*. The specimen has a faint yellow medulla which reacts K+ bright yellow, which slowly becomes bright orange. No colour response is elicited with C, and KC may bleach the K reaction slightly. P gives a red to blood-red colour. All three spots are pinkish-brown on developed TLC plates, and FB-1 and -2 are presumed to be β-orcinol depsidones.

(b) The "chalybaeizans unknown"

This substance is present in all specimens of *X. chalybaeizans* (140), many specimens of *X. exornata* (30), and in part of *X. hyporhytida* (Hale, 1971), and is therefore widely distributed within the Karoo. The "chalybaeizans unknown" reacts with K to give an immediate rich-yellow to yellow-orange colour which does not darken with time (c.f. salazinic acid). It is P+ orange, and is weakly to moderately white fluorescent in longwave UV.

(c) PQ-4

PQ-4 was found with hypostictic acid in a few specimens of *X. adhaerens*.

(d) Q-1

This unknown was reported for the first time by Culberson and Hale (1973). Q-1 was found in association with hypoprotocetraric and 4-O-demethylnotatic acids in a few (25) specimens of *X. perspersa*.

(e) St-1

St-1 occurs in major amounts in the holotype specimen of *Parmelia steineri* Gyel. (= *X. molliuscula*). This compound occurs in trace to major amounts with stictic and constictic acid in *X. adhaerens* (10), *X. conspersa* (1), *X. constrictans* p.p. (13), and *X. molliuscula* (5).

(iii) Pigments

(a) Endo-1, endo-2, endo-3 and endo-4

One to all of these pigments occur in *X. dichromatica*, and usually all of them occur in both *X. endomiltodes* and *X. ianthina*. These pigments, suspected to be anthraquinones, vary from maroon to violet in colour and change to purple on application of the K reagent. Endo-1 to -4 are distributed in the eastern part of the Karoo in *X. dichromatica*, which is also common in Lesotho and surrounding areas. The other two species occur on the southern and western margins respectively.

(b) Sch-1 and sch-2

Sch-1 and sch-2 occur together in some specimens of *X. schenckiana* and *X. colorata*. These pigments cause the medulla adjacent to the lower cortex to be an orangy-brown colour. Occasionally much of the medulla is this colour. The colour changes to violet with K. Sch-1 is strongly yellow fluorescent in longwave UV, whereas sch-2 absorbs this radiation and appears as a dark spot. It is possible that the yellow-green pigment SV-1 (Culberson, 1972) correspond to one or both of these pigments.

(iv) Suspected Aliphatic Acids and Lactones

(a) Subd-1 to subd-6

These substances are present in the widespread *X. subdecipiens* (15 specimens). Subd-1 was always found in major amounts. Subd-2 was present in minor to major amounts, and each of the remaining compounds (subd-3 to subd-6) was either absent, or present in varying amounts. There has been a suggestion that subd-1 and subd-2 are identical to pseudonorrangiformic and rangiformic acids respectively (Kurokawa and Filson, 1975). It is also possible that subd-1 and subd-2 are the same as PP-2 and PP-1 respectively, unknowns found in *Neofusoelia pulloides* (Essl.) Essl. (Esslinger, 1974, 1977). A distinctive feature of subd-1 is its white colour on developed plates in longwave UV.

(b) XG-1 and XG-2

These two substances occur in the specimens assigned to *X. globulifera*. These specimens were found on the southern and western margins of the Karoo. In the original description (Kurokawa and Filson, 1975), this species was considered to contain caperatic acid and an unknown fatty acid. Although caperatic acid was not detected, it was considered best to place the specimens from the Cape in *X. globulifera*, until these substances can be studied more definitively.

(v) Substances of Unknown Affinity

(a) Brun-1, brun-2 and brun-3

These three substances occur in the type strain of *X. brunnthaleri*. Brun-1 and brun-2 are always present in detectable amounts, but often brun-3 *is not present. The type strain of this* species is widespread in the Karoo, and is common north of the Roggeveld-Sneeuwberg escarpment. Brun-1 to -3 are negative to all the spot reagents, but quench the layer fluorescence of the TLC plates in shortwave UV, and are pale yellowish in colour on developed plates. These substances appear similar to the unknowns in *Pseudoparmelia vanderbylii* (Zahlbr.) Hale, but the R_f values differ.

(b) Tha-1, tha-2 and tha-3

These unknown compounds occur consistently with Th-1 in *X. hypomelaena* and *X. ianthina*, on the western margin of the Karoo. Tha-1, -2 and -3 are all white fluorescent in longwave UV, but don't show up *in any other way. (i.e. They do not* quench the plate fluorescence in shortwave UV, and are invisible on the TLC plates not only before (when either dry or wet) but also after development.)

2.6 THE BIOSYNTHESIS OF LICHEN DEPSIDES AND DEPSIDONES

Of all the substances found in lichens (Culberson, 1969a, 1970; Culberson, Culberson and Johnson, 1977), the lichen depsides and depsidones are the most typical. With the possible exception of the fungal nidulin and mitorubrins (Turner, 1971), with orsellinic acid derivatives as the A-rings, these substances are unique to the lichens. Plant depsides are unrelated substances with subunits derived from the shikimate pathway (Sondheimer, 1964; Haslam, 1974). *Lichen depsides and depsidones* are polyketides derived from the acetate-polymalonate pathway.

2.6.1 DEPSIDES

A single mechanism has been proposed for the formation of lichen depsides (see review by Mosbach (1973)). This involves the biosynthesis of separate orsellinate derivatives, which are esterified subsequently. The formation of the tetraketide subunit involves the condensation of one acetyl-S-CoA with three consecutive malonyl-S-CoA molecules with the concomitant evolution of carbon dioxide at each condensation cycle (Mosbach, 1964). This process is similar to fatty acid synthesis, but the reduction, dehydration, and final (optional) reduction steps, are lacking. In analogy to *fatty acid synthesis, tetraketide formation is* thought to take place on a multienzyme complex. In fact a single multienzyme particle which synthesizes the related polyketide, 6-methylsalicyclic acid has been isolated from *Penicillium patulum* G. Bain (Dimroth et al., 1970).

The stabilization of the tetraketide-S-enzyme complex may involve chelation to a suitable metallic ion within this complex (Bu'lock, 1967). "Extra" carbon atoms, such as those in the 3 positions of β-orcinol depsides, are probably incorporated at the polyketide stage, as the interketo methylene hydrogens are acidic. Labelling experiments carried out by Yamazaki et al. (1965), show that [^{14}C] formate is incorporated specifically into the 3 and 3' methyl groups, and the 1' methyl ester of *atranorin. Other work supporting this notion was done by* Yamazaki and Shibata (1966), who showed that tritiated 3-methylorsellinic and mitorubrins (Turner, 1971), with orsellinic acid derivatives as the A-rings, these substances are unique to the lichens. Plant depsides are unrelated substances with subunits derived from the shikimate pathway (Sondheimer, 1964; Haslam, 1974). Lichen depsides and depsidones are polyketides derived from the acetate-polymalonate pathway.

2.6.1 DEPSIDES

A single mechanism has been proposed for the formation of lichen depsides (see review by Mosbach (1973)). This involves the biosynthesis of separate orsellinate derivatives, which are esterified subsequently. The formation of the tetraketide subunit involves the condensation of one acetyl-S-CoA with three consecutive malonyl-S-CoA molecules with the concomitant evolution of carbon dioxide at each condensation cycle (Mosbach, 1964). This process is similar to fatty acid synthesis, but the reduction, dehydration, and final (optional) reduction steps, are lacking. In analogy to fatty acid synthesis, tetraketide formation is thought to take place on a multienzyme complex. In fact a single multienzyme particle which synthesizes the related polyketide, 6-methylsalicyclic acid has been isolated from *Penicillium patulum* G. Bain (Dimroth et al., 1970).

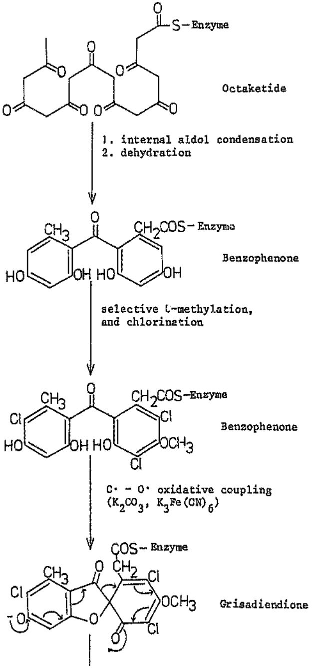
The stabilization of the tetraketide-S-enzyme complex may involve chelation to a suitable metallic ion within this complex (Bu'lock, 1967). "Extra" carbon atoms, such as those in the 3 positions of β-orcinol depsides, are probably incorporated at the polyketide stage, as the interketo methylene hydrogens are acidic. Labelling experiments carried out by Yamazaki et al. (1965), show that $[^{14}C]$ formate is incorporated specifically into the 3 and 3' methyl groups, and the 1' methyl ester of atranorin. Other work supporting this notion was done by Yamazaki and Shibata (1966), who showed that tritiated 3-methylorsellinic acid, and not tritiated orsellinic acid, was incorporated into atranorin.

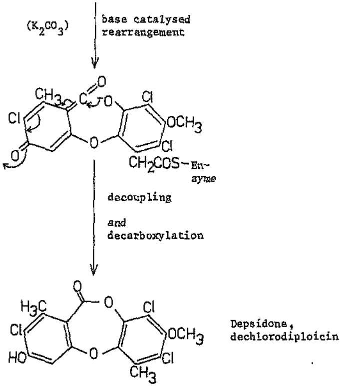
An internal 2-7 aldol condensation followed by dehydration results in an orsellinate-S-enzyme complex. Although no information is available for the lichen fungi, the "extra" aromatic hydroxyls, such as those of the orcinol and β-orcinol *meta*-depsides, are probably inserted after ring closure and aromatization. Evidence in support of this statement can be drawn from analagous situations in the fungi, where aromatic compounds are catabolized by monooxygenases ("mixed function oxygenases") (Hayaishi, 1974; Cerniglia et al., 1978). Esterification of identical or different subunits then takes place on a depside synthetase which may be separate from, or part of the multi-enzyme complex.

2.6.2 DEPSIDONES

As is the case with depsides, the mode of depsidone formation is unknown. However it seems most likely that they are synthesized via "the corresponding depsides" by oxidative coupling on either separate depside dehydrogenases, or depsidone multi-enzyme complexes involving the bound depside precursors. In the latter case esterification may occur prior to oxidative coupling or vice versa. This hypothesis provides a plausible explanation for all the known depsidones, if one includes the possibility of decarboxylation and chlorination in several cases.

An alternative biosynthetic mechanism has been proposed for depsidones, which involves an internal aldol condensation of an octaketide precursor to give benzophenones. These benzophenones are supposed to undergo oxidative coupling to give grisadiendiones which subsequently rearrange into depsidones (Sala and Sargent, 1978b). This hypothesis is based on chemical reactions, of the type first observed in the synthesis of diploicin (Hendrickson et al., 1972). A reaction sequence leading to dechlorodiploicin (Sala and Sargent, 1978a) is shown in scheme 1.





Scheme 1 Hypothetical *pathway for* the biosynthesis of dechlorodiploicin involving a *rearrangement*, analogous to base catalysed rearrangements, of grisadien*diones*.

Prerequisites for this type of rearrangement are (a) O-methylation at the 2' position and (b) free hydroxyls at the 4 and 4' positions of the final depsidone, at or before the grisan stage. The absence of O-methylation at the 2' position would result in a B-ring phenolate anion, *which is a poor* leaving group (Sala and Sargent, 1978b; Fig. 12).

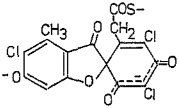
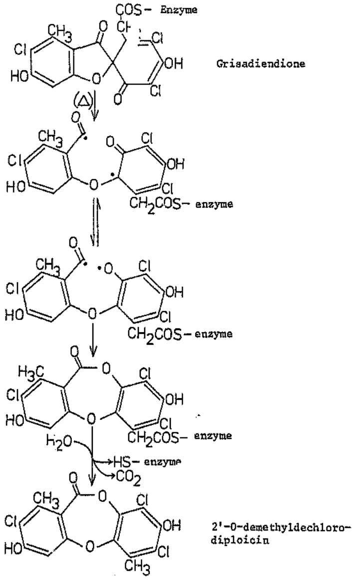


Fig. 12 The putative grisan precursor of 2'-O-demethyldechlorodiploicin (Adapted from Sala and Sargent, 1978b)

The free hydroxyl at the 4' position is required for the formation of the grisadiendione, and both the 4 and 4' hydroxyls are required for anion formation during the various stages of the rearrangement (scheme 1).

The restrictive conditions of the base catalysed synthetic analogy (scheme 1) do not apply to a rearrangement by a radical mechanism, which is brought about by heat under synthetic conditions. Using the above example of the grisan precursor of 2'-O-demethyldechlorodiploicin (fig. 12) the radical rearrangement would proceed as in scheme 2. (The various types of free radical reactions known in biological systems are summarized in Pryor (1976)).



Scheme 2 Hypothetical pathway for the biosynthesis of 2'-0-demethyldechlorodiploicin by a free radical rearrangement from the grisan precursor.

Although the derivation of 1'-decarboxydepsidones from octaketides seems quite feasible, most depsidones are carboxylated in the 1' position. It seems more expedient to regard these few 1' decarboxydepsidones as decarboxylated products derived from coupled orsellinic acid derivatives, particularly as the 1' carboxyl group of depsides is part of the tetraketide skeleton of the B-ring and not an "extra" carbon (Yamazaki et al., 1965). *Other features which do not* support this proposal are: (a) In addition to the "extra" 1' carboxylation of most depsidones, the terminal (thioester) carboxyl group of the original polyketide chain has to be removed as *side chains in 6' position are* always composed of uneven numbers of carbon atoms (e.g. last step of scheme 2). No such decarboxylations are required for the route involving separately formed orsellinate subunits. (b) Several depside-depsidone pairs are known in the lichens, but these occur together only in occasional species. A tentative example in *Xanthoparmelia*, is the pair *X. burmeisteri* - *X. hypoprotocetrarica*, containing the depsides 4-O-demethylbarbatic and barbatic acids and the respective corresponding depsidones hypoprotocetraric and 4-O-methylhypoprotocetraric acids respectively. However these two classes of corresponding compounds have never been found together in a single specimen. Examples of known pairs are: atranorin-methyl virensate; 5-chloroatranorin - physciosporin; 4-O-demethylbarbatic acid - hypoprotocetraric acid; barbatic acid - 4-O-methylhypoprotocetraric acid; obtusatic acid - notatic acid; norobtusatic acid - 4-O-demethylnotatic acid; sphaerophorin - grayanic acid; microphyllinic acid - α-collatolic acid; and olivetoric acid - physodic acid.

Thus it appears that the most likely route for depsidone biosynthesis occurs via separately synthesized orsellinic acid subunits.

2.7 THE BIOLOGICAL SIGNIFICANCE OF LICHEN SUBSTANCES

Since the lichen secondary metabolites are so important in the taxonomy of the Karoo Xanthoparmeliae, it is pertinent to discuss briefly the reasons postulated for their presence.

(i) Lichen Substances as Secondary Metabolites with no Function

The mineral nutrient deficient metabolism in most lichens causes the excess fixed carbon from the algal component. to be spilled over into lichen secondary metabolites, which have no other function (Mosbach, 1973). It has also been tentatively suggested that polyketides are often produced instead of fatty acids due to the low level of reduced nicotinamide adenine dinucleotide phosphate ($NADPH_2$) available. This suggestion arose from an earlier study concerning the production of palmitic and orsellinic acids by *Penicillium baarnense* v. Beyma under various cultural conditions (Mosbach and Bävertoft, 1971). The medium with nitrate as the sole source of nitrogen, resulted in the production of orsellinic acid, whereas that with reduced nitrogen (ammonia and amino acids) resulted in palmitic acid production. This was interpreted as being a competitive effect, $NADPH^+$ being used for both nitrate and polyketide reduction.

(ii) Lichen Substances as Storage Compounds

While esters of fatty acids are known to be storage compounds in plants and animals, it is not known whether the fatty acids and fatty acid lactones found in lichens have a similar function.

There is some evidence to indicate that depsides (and therefore also depsidones) may behave as storage compounds. For instance an orsellinate depside hydrolase (depside esterase) has been detected in cell free extracts of the lichen *Lasallia pustulata* (L) Mér. and the cultured phycobiont of *Lasallia papulosa* (Ach.) Llano. An orsellinate decarboxylase was present also in the former (whole lichen) extract (Mosbach and Ehrensvärd, 1966). Although the further degradation of the resulting aromatic resorcinols has not been reported for lichens, it is difficult to understand the reason for the (oxidative?) decarboxylation, unless further catabolism is to take place. The catabolism of aromatic compounds by bacteria is relatively well documented (Clarke and Ornston, 1975; Hayaishi, 1974; Doelle, 1975), but relatively few reports have emerged for fungi and none are known for lichenized fungi. For instance orcinol is catabolized in the following manner by *Pseudomonas putida* (Trev.) Mig. (Fig. 13).

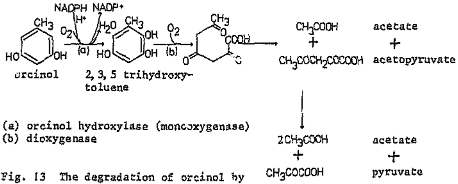


Fig. 13 The degradation of orcinol by *Pseudomonas putida* (Ohta et al., 1975)

The second compound in Fig. 13 may also arise by oxidative decarboxylation of orsellinic acid, in the manner reported by Buswell et al. (1979) for vanillin. Shortly afterwards (Buswell and Eriksson, 1979) the white rot basidiomycete was reported to demethylate the resultant 2-methoxyhydroquinone, and the 2-hydroxyhydroquinone ring opened between the carbons carrying *ortho* hydroxyl groups.

If lichen substances are indeed catabolized fully, then it is also possible that they serve as carbon and energy reserves, enabling lichens to grow when immediately fixed carbon is not available (for example on moist nights). The unexpectedly high incorporation rates of radioactive precursors into depsides (Mosbach, 1964; Fox and Mosbach, 1967), may be circumstantial evidence supporting this impression.

(iii) Protection of the Algal layer

The phycobiont of most lichens are sensitive to excessive light intensities in culture, and the cortical pigments have long been thought to cut this down (Hale, 1974e). The usnic acid in the upper cortices of the Xanthoparmeliae absorbs light from ultraviolet wavelengths extending slightly into the purple end of the visible region, giving it its pale yellow colour. Usnic acid may therefore be most effective in protecting the algal layer from damaging ultraviolet light.

(iv) Aeration of the Algal Layer when Wet

Another putative function of lichen substances was expounded by Goebel in 1926 (see Blum (1973) p. 387). The hyphae in the algal layer and part of the medulla are encrusted with hydrophobic lichen substances, which trap air between them and ensure an adequate air supply to the algae when the thallus is wet. According to this theory, this does not prevent water movement to the algae, because the hyphal walls act as wicks

(v) Metal Ion Chelation

Contrary to popular belief, depsides and depsidones are slightly soluble (5-57 ppm) in water (Iskandar and Syers, 1971), and are able to chelate metallic ions derived from various types of igneous rocks (Iskandar and Syers, 1972; Syers and Iskandar, 1973). Thus the lichen substances may be of importance in the mineral nutrition of saxicolous and terricolous lichens in particular.

(vi) Palatability

The possibility that lichen substances render lichens unpalatable to lichen grazers has been reviewed by Gerson and Seaward (1977), and Richardson and Young (1977). A report by Wessels et al. (1979) indicates that *Teloschistes capensis* (L.f.) Malme is grazed by two Tenebrionid beetles in the Namib desert. Huneck and Follman (1971) indicate that at least part of this taxon contains both parietin and salazinic acid. Mite and possibly Curculionid damage was observed in the Karoo Xanthoparmeliae, but it is not known if this damage constituted grazing, burrow/nest building or the like. It is clear however that lichen substances at best only partially protect lichens from grazers of all kinds.

(vii) The Antimicrobial Activity

The Antimicrobial activity of lichen substances has been reviewed by Vartia (1973). They are often active against gram positive, but characteristically inactive against gram negative bacteria. Some of these compounds are also active against fungi. The β-orcinol depsidones, so important in the taxonomy of the Karoo Xanthoparmeliae, appear to be only weakly active against gram positive bacteria, but the universal usnic acid is an active antimicrobial agent.

(viii) Inhibition of Moss Protonema Growth

Mosses are important competitors of lichens, and the report that some lichen substances retard the growth of moss protonemata

(Lawrey, 1977) may give certain lichens a distinct advantage over mosses. However large numbers of pure lichen substances need to be tested before conclusions can be drawn about the relationship between retardation of protonema growth and lichen substance structure.

(ix) Inhibition of Plant Root Growth

The inhibition of mitosis in plant roots by lichen substances has been reported (Sturelid and Lundström, 1972; Reddy et al., 1978) and may confer an advantage on lichens growing in rock cracks, and retard the colonization of lichen consolidated soil by higher plants.

Whatever the functions of the lichen substances, the ecological advantages (if any) conferred on lichens by the production of these substances, must play a role in (a) the selection of these compounds during the course of their evolution, and (b) the adaption of the species to the particular environments (niches) in which they have come to grow.

2.8 BIOGENIC RELATIONSHIPS AMONG THE LICHEN DEPSIDES AND DEPSIDONES

2.8.1 THE RANK OF DEPSIDES AND DEPSIDONES

Any attempt at placing the known depsides and depsidones in order of complexity will require a sound knowledge of the enzymes and intermediates involved in their synthesis. Since enzymes are proteins, a biosynthetic pathway involving more enzymes will require more genetic material to code for the enzymes, and therefore the substance could be regarded as more advanced biogenetically. It is possible, but unlikely, that within a genus the synthesis of a simpler compound may require a greater total amino acid sequence, than the synthesis of a more complex compound. On the other hand, it is very likely that the biosynthesis of a single compound is carried out by different total amino acid sequences with the sequence differing in similarity in different genera, and even more so in different orders. This may be so, in spite of an identical biosynthetic pathway involving similar types of enzymes as catalysts. For instance the intermediates and types of enzymes involved in the biosynthesis of lecanoric acid in the genera *Roccella* and *Xanthoparmelia* are likely to be the same, but variations in the amino acid sequences of each corresponding enzyme in the biosynthetic pathway are expected. Thus, in both genera, the final enzymes of the lecanoric acid biosynthetic pathway, "lecanorate orsellinate dehydrolase", are expected to be very similar to each other in three dimensional shape, but the amino acid sequences of the protein chains are expected to differ from each other along non-critical segments. This difference will be far less marked in two species from the same genus e.g. *X. joranadia* (Nash) Hale and *X. worcesteri*, unless of course, these two "species" are mere morphological variants of each other. In this case each corresponding amino acid residue would be identical in each respective enzyme from each "species". Since the production of the lichen substances is not critical in the survival of a lichen, a mutation in the DNA sequence (the genetic material) concerned with the coding of the enzymes involved, may result in a change in an amino acid residue (or more rarely deletion or duplication of lengths of amino acid residues due to double cross-over errors) in one of these enzymes. Even if this terminates the production of the lichen substance(s) it had previously been able to synthesize, the lichen is still able to survive and reproduce sexually, disseminating the new genetic material and allowing it to be put to the test of natural selection. Conversely, even a slightly deleterious mutation in a protein essential to the normal function of metabolic pathways, such as cytochrome c, would result in the loss of the new genetic material (death of the individual). Thus the cytochrome c amino acid sequence would be expected to vary very little, at least among the members of the Lecanorales. (The above discussion is based on the analogous situation of the evolution of haemoglobin in mammals (Zuckerkandl, 1968)).

Some biosynthetic steps may be universal among depside/depsidone producing lichens, but only apparent in the depside/depsidone chemistry of some species. For example, aromatic hydroxylation maybe universal in the catabolism of aromatic lichen substances, but only those species with *meta*-depside synthetases are able to incorporate such (putative catabolic) hydroxylated products into *meta*-depsides. It is also possible that physodalic ("Acetoprotocetraric"), succinoprotocetraric and fumarprotocetraric acids are equally advanced, as acetyl-S-CoA, succinyl-S-CoA, succinic and fumaric acids are readily available Tricarboxylic Acid Cycle intermediates. A non-specific dehydrolase may be responsible for their esterification to the 3' carbinol of protocetraric acid. Another possibility that cannot be excluded is that certain lichens may possess all the genetic information required for the synthesis of any depside or depsidone, but that only a few are actually produced, due to the repression of appropriate parts of the genetic material. Under certain environmental conditions, synthesis of the enzymes responsible for the formation of one compound may be repressed, and that of another activated. However segments of *Xanthoparmelia cumberlandia* (Gyel.) Hale transplanted to other sites in Ontario (Canada), maintained their production of stictic and constictic acids (Fahselt, 1979).

2.8.2 THE USE OF CHEMISTRY ABOVE THE LEVEL OF SPECIES

In the absence of the above types of information it has become customary to speculate on the biogenic position of depsides and depsidones based either on the structure, or on the distribution of these substances within the orders and families of lichenized fungi. The structure premise breaks down if the structures are not closely related, and the premise that primitive families must contain "primitive" substances is based on the present lichen classifications (e.g. Barr (1976)), which may not reflect the order of antiquity of the various taxa. Nevertheless some lichen orders, families and genera show distinct chemical trends which are very useful in defining these taxa. A clear cut example is the genus *Dirinaria* (Tuck.) Clem. which besides being morphologically distinct from the remainder of the Physciaceae, is also chemically distinct in that all representatives of this genus produce orcinol *para*- and *meta*-depsides which are unknown in the rest of this family (Awasthi, 1975; Swinscow and Krog, 1978). With such a clearcut morphological and chemical correlation, the chemical evidence is undisputed. However there are many instances where the evidence is not as clear cut, but trends are observable. These trends can be accurately evaluated only if the taxon is exhaustively studied for chemical variation (Culberson and Culberson, 1970; Hawksworth, 1976, pp. 158-161; Esslinger, 1977, pp. 30-33).

2.8.3 THE USE OF CHEMISTRY AT OR BELOW SPECIES LEVEL

There seems to be universal agreement among lichenologists that chemistry should be studied in lichen taxonomy, particularly where there is great chemical diversity. However there seems to be no agreement on the weighting which should be accorded to chemical data.

Hawksworth (1976) has presented an exhaustive discussion on this point and has laid down guidelines for the use of chemistry in conjunction with morphology and distribution in determining species or varieties, the two taxa recognized in this category.

The Karoo Xanthoparmeliae show four types of chemical variation. (a) Replacement of one substance or set of substances by another closely related substance or set of substances, without the existence of a progressive changeover. For example *X. constrictans* consists of two chemical strains, one with salazinic acid which is replaced by stictic and constictic (4-O-methylsalazinic) acids in the other. Norstictic acid is accessory in both strains. (b) Replacement of one substance or set of substances with another distantly related or unrelated substance or set of substances. Here an example is the *X. hypoleia* group. with *X. hypoleia* itself containing the β-orcinol depsidones, protocetraric and virensic acids, which are replaced by the β-orcinol depsides barbatic and 4-O-demethylbarbatic acids in *X. burmeisteri*, and by the orcinol depside evernic acid in *X. dysprosa*. (c) Chemosyndromic variation (Culberson and Culberson, 1976). This type of chemical variation is characterized by the existence of a series of related compounds, one to a few of any of these being present in major amounts, and the remainder being present in trace amounts or absent. Sorting the specimens into chemical strains, highlights a progressive change from one set of lichen substances into another. Chemosyndromic variation may occur within one species (see below), one group of species (such as the *Neofuscelia pulla* (Ach.) Essl. group; Culberson, Culberson and Esslinger, 1977), or even one genus (for example *Cetrelia* Culb. et Culb.; Culberson and Culberson, 1976). In the latter two cases the discontinuities in the chemosyndromic series, together with morphological differences, warrant the recognition of species. Chemosyndromic variation of β-orcinol depsides occurs in *X. brunnthaleri* p.p. in the Karoo. Here barbatic, 4-O-demethylbarbatic acids, and barb-1, -2, -3 and -4 occur together in varying combinations of major amounts of one to four of these substances. The remaining substances maybe present in minor amounts or absent, but the maximum number of these compounds in any one specimen was always four, even counting those present in moderate amounts. Superimposed on this chemosyndromic variation is the rare presence of brun-1 and brun-2, which occur alone in the type strain of this species.

Another type of chemosyndromic variation, involving virensic acid, and both protocetraric acid and its 3' carbinol esters, occurs in *X. subconspersa*. In this example major amounts of succinoprotocetraric, protocetraric and less frequently fumarprotocetraric acids are present in various combinations or alone. Sometimes minor amounts of physodalic and/or virensic acids are produced as accessories *(see below)*.

(d) *Accessory substances*. On the whole these substances occur in lesser amounts and are frequently absent in species producing them. The best example is norstictic acid which is a common accessory in species producing salazinic acid on the one hand and those producing stictic and constictic acids on the other.

In this study only chemical variation of the (b) type has been used to delineate species in the absence of other evidence. Replacement of one compound with another closely related compound ((a) type) has been used to delineate species only when there are clearcut distributional differences.

3. MORPHOLOGY

3.1 THALLUS

3.1.1 Thallus Habit

The Karoo Xanthoparmelias vary in the diversity of thallus habits displayed. The term "habit" is here used in a broad sense, covering adnation, appression, lobe width, degree of lobe convexity, degree of lobe elevation, degree of areolation and surface rugosity, thickness; extent of lobe overlap, and length in relation to the width of the lobes.

(i) Adnation and Appression

Several of the habit characters are used in various states which are expressed verbally and which require some elaboration. The terms "appressed" and "adnate" are used in the sense of Esslinger (1974, 1977) for two related but distinct thallus conditions. The term appressed refers to the closeness of fit to the substrate, while adnation describes the tightness of attachment. Although closely appressed thalli are also often tightly adnate, the two do not necessarily correlate. These terms apply most satisfactorily to thalli that are more or less evenly appressed. Thalli with ascending lobes, such as some specimens of *X. hyporhytida, X. subconspersa* and the members of the *X. hypoleia* group, may be tightly adnate on one portion of lobe, with the free, (aerial) portion being not adnate at all. These two terms apply only to the thallus-substrate, not the thallus-thallus interface. For example, a thallus may have overlapping (imbricate) lobes which may be quite tightly adnate upon one another, but loosely adnate upon the substrate (e.g. *X. tasmanica*).

The states of adnation used in this study are somewhat different to those of previous studies (Esslinger, 1974, 1977), and are defined as follows: (a) Loosely adnate - thallus removable by hand, intact or in large pieces; (b) moderately adnate - thallus removable with a knife, intact or in large pieces; (c) tightly adnate - thallus removable with a knife, but this resulting in the total destruction of the thallus into individual lobes and lobe fragments; (d) subcrustose - thallus not removable with a knife, always being collected with the substrate, but the lower cortex largely present below; (e) crustose - as in (d) above, but the lower cortex largely absent, being present at the lobe tips only.

Only two character states of appression are used: (a) closely appressed, when most of the undersurface is less than ½ mm from the substrate and (b) when appression is not mentioned because most of the undersurface is more than ½ mm from the substrate. The term ignores soil accumulated under the thallus.

(ii) Lobe Overlap

The degree of lobe overlap has been described in four states: (a) Discrete - lobes never or only occasionally overlapped, often not in contact with the next lobe; (b) Contiguous - lobes mostly in contact with each other, and often overlapped slightly, but less than one quarter of the lobe surface area covered by other lobes (This is a common condition of tightly adnate individuals and is often not mentioned); (c) imbricate - lobes always covered by large areas of each other, the thallus often being a few lobe layers thick; (d) highly imbricate - a state used to describe a thallus with more than a few lobe layers, which are usually quite loosely layered.

(iii) Lobe Dimensions

The length of the marginal or upper lobes are indicated qualitatively by four terms: (a) elongate indicates that the lobes are from slightly longer than broad to about five times longer than broad; (b) very elongate refers to lobes that are five to ten times longer than broad; (c) sublinear lobes are those which are about 1 mm broad throughout most of the visible part of the thallus, and (d) linear lobes, those which are 0.3 mm wide or less over long distances of lobe.

(iv) Habit Variations - Crustose/Subcrustose

The Karoo species of *Xanthoparmelia* vary from crustose to foliose to fruticose. Although no single species exhibits this full range of variation, *X. constrictans* comes close, varying from subcrustose to subfruticose.

There are nine species which exhibit crustose or subcrustose habits five of which do so consistently, the remainder grading into foliose habits. The thalli of these specimens are often lobate at the margins, with the lobes approximately 1 mm wide, and 60-200 µm thick. However some bullate areoles of *X. adhaerens*, *X. perspersa* and *X. worcesteri* may become up to 500 µm thick. *X. heterodoxa* and *X. ralla* are unusual in having very thin lobes (always less than 100 µm thick) with very thin medullae.

(v) Subcrustose to Foliose Variation

Four species, *X. chalybaeizans*, *X. constrictans*, *X. perspersa* and *X. worcesteri*, have been found to vary from subcrustose to foliose. *X. constrictans* often exhibits two foliose forms, the first having sublinear lobes, with constrictions just beyond the branch points, and the second, linear-lobed with the constrictions not conspicuous. Preliminary evidence indicates that these two states intergrade with each other and the subcrustose forms, but this concept is only tentative as more specimens from the southern and south-western Cape are required. The other three [illegible]ies are similar in subcrustose to foliose habits, but differ [illegible]nce and distribution of the *subcrustose states* (the folio[illegible], distributed throughout their respective ranges in all three [illegible]). The foliose forms of these three species commonly have lobe widths between 2 and 4 mm. This feature is also frequent for *X. subdecipiens* and *X. dichromatica*, species with similar foliose habits, but which lack the subcrustose condition.

(vi) Dorsiventral to Terete Lobe Variation

The proportion of terete to dorsiventral lobe varies in *X. molliuscula*. Thalli with limited terete lobe development appear foliose, whereas those composed largely of terete lobes give a fruticose impression. Sometimes terete lobes may arise rather abruptly from dorsiventral sections and these may resemble coarse *isidia, but this* species is non-isidiate.

A hint of terete lobe formation has been seen in *X. tasmanica*. Another terete lobes species, *X. amphixanthoides* (J. Stein. et Zahlbr.) Hale, was not found in the study area.

(vii) The Variation of the *X. hypoleia* Group

In the *X. hypoleia* group, (excluding *X. columnata*), another type of foliose variation occurs. In this case the more tightly adnate thalli are composed of subascending lobes, and loosely adnate specimens are composed of sublinear, less commonly linear lobes which are highly imbricate. *X. burmeisteri* and *X. dysprosa* have been collected in the latter condition, but are otherwise represented too sparsely to assess their variability. *X. hypomelaena* tends to have broader lobes which are imbricate (plate 16 A, C, and D) resembling *X. tasmanica*.

(viii) Variations on Convex Lobes

A rather peculiar thallus habit is exhibited by *X. columnata* and part of *X. exornata*. In this case the thalli consist of discrete, evenly appressed, dichotomously branching convex lobes (plate 18 A and D, 36[illegible]). This habit may also be highly imbricate, (e.g. *X. exornata*; plate 18C) and the convex habit also grades into a more normally foliose habit (with plane lobes) in *X. exornata* (plate 18B).

Several Neofuscaliae have similar but not identical convex-lobed habits (Esslinger, 1974, 1977), but the variability of these, if any, is unknown.

(ix) Horizontal to Subascending Lobe Variation

Two species resemble *Omphalodium hottentottum* (Ach.) Flot. in part of their habit range, but are not as robust and mostly lack the single holdfast or umbilicus, which is typical for this species. One of these species, *X. subconspersa*, is well known, and ranges from normally foliose to a condition with subascending lobes, where the holdfasts are present at the bases of these lobes (plate 21; 22C, and D; 23A, and B). Other directions of morphological variation in *X. subconspersa* are in lobe thickness (80-700 µm), lobe width (1-8 mm) and the amount of blackening on the reverse surface. The other species, *X. hyporhytida*, is scantily represented in the present collections. However, the holotype has subascending lobes and other variants resemble loosely adnate forms of *X. hypoleia* (Hale, 1971; and the two examined specimens).

(x) Species with Little Habit Variation

Despite the fact that the above types of habit variation occur frequently in the Karoo Xanthoparmeliae, there are several species which are constant in thallus habit, including some of those most characteristic of the area. The most conspicuous of these are *X. schenckiana* and the closely related *X. colorata*, with large, evenly appressed, tightly adnate thalli, and very elongate marginal lobes 4-6 mm broad (plate 31A, B, C; 32C). The similar *X. psoromifera* also displays a relatively constant foliose habit (plate 31D), with similar marginal lobes 3-6 mm wide. The much smaller *X. brunnthaleri*, exhibits very elongate marginal lobes, conspicuously 1-2½ mm broad, which are evenly and closely appressed (plate 25). All of these species are often rugose in the interior.

(xi) Similarities between *Xanthoparmelia*, *Pseudoparmelia* and *Neofuscelia*

The saxicolous members of the genus *Pseudoparmelia* resemble the normally foliose Xanthoparmeliae, but the variation within and between the former species appears to be conservative (Hale and Kurokawa, 1964; Hale, 1976a).

Three species in particular resemble three Xanthoparmeliae, at least in part. These are: (a) *Ps. condyloides* (Kurok.) Hale resembling *X. chalybaeizans*, both being pale brown below, and containing salazinic acid and the "chalybaeizans unknown" in the medulla. In addition atranorin is accessory in *X. chalybaeizans*, but consistent in the upper cortex of *Ps. condyloides*, which lacks usnic acid. (b) *Ps. molybdiza* (Nyl.) Hale which resembles *X. worcesteri*. Both contain lecanoric acid in the medulla and have black or pale undersurfaces, but the subcrustose habit has not been reported for *Ps. molybdiza*. An isidiate counterpart is well known for the *Pseudoparmelia* (*Ps. annexa* (Kurok.) Hale), but is not known in southern Africa for the *Xanthoparmelia*. (*X. joranadia* (Nash) Hale is known in North America, however (Nash, 1974b)). (c) *Pseudoparmelia chlorea* (Stiz.) ad int. which has a coarse-pruinose obverse surface similar to that of the *X. schenckiana* group. The former species differs morphologically and in the chemistry of the upper cortex (atranorin) and medulla (two unknowns).

The range of habits displayed by the Neofusceliae is similar to that of the Xanthoparmeliae, except ascending-lobed and maculate habits are lacking in the former. The orcinol depside and depsidone chemistry is far more pronounced in *Neofuscelia* than in either *Pseudoparmelia* or *Xanthoparmelia*. Two crustose/subcrustose species of *Neofuscelia* resemble two Xanthoparmeliae: (a) *Neofuscelia applicata* (Stiz.) Essl. resembles *Xanthoparmelia ralla*, and (b) *Neofuscelia melancholica* (J. Stein. et Zahlbr.) Essl. is close to *Xanthoparmelia leptoplaca*. Both differ from their respective counterparts in cortical chemistry. *Pseudoparmelia violacea* (Kurok.) Hale, which is devoid of cortical substances (Hale, 1976a) resembles *Xanthoparmelia endomiltodes*, *X. ianthina* and *X. dichromatica*.

3.1.2 Epicortex

Most of the species have been examined for the presence of an epicortex with the scanning electron microscope (SEM). The condition of this structure varies from being rudimentary to variously pored (plates 1 and 2; Hale, 1973, figs. 53-60). The distinction between a pored epicortex and rudimentary type is rather unclear in some cases, and a continuum of intermediate states exists in species with pored and rudimentary epicortices. Species which are consistently pored-epicorticate are: *X. brunnthaleri*, *X. burmeisteri*, *X. columnata*, *X. conspersa*, *X. contrictans*, *X. dichromatica*, *X. dysprosa*, *X. endomiltodes*, *X. exornata*, *X. globulifera*, *X. hypoleia*, *X. hypomelaena*, *X. hypoprotocetrarica*, *X. hyporhytida*, *X. ianthina*, *X. leucostigma*, *X. molliuscula*, *X. scabrosa*, *X. subconspersa*, *X. subdecipiens*, *X. subramigera*, and *X. tasmanica*. *X. exornata* is unusual in its pored epicortex, in that the porosity is restricted to finite areas in an otherwise unpored epicortex (plate 4A, B and D). On older lobes, these pored areas may break open and expose medullary tissue, and thus resemble pseudocyphellae. This process appears to be a character of moribundity, rather than being genetically controlled as is presumed for pseudocyphellae. Pseudocyphellae are also associated with reticulate maculation, ridging or fissures.

Five species exhibit both pored and rudimentary epicortices. *X. adhaerens* and *X. psoromifera* display the least amount of variation, being highly pored to rudimentary. The other species, *X. chalybaeizans*, *X. perspersa* and *X. worcesteri* display the full range of variation, sometimes on a single thallus or lobe (plate 5A). The rudimentary epicortex is very common for subcrustose forms of *X. perspersa* and *X. worcesteri*, but *X. chalybaeizans* shows this habit on tightly adnate foliose forms (plate 3B; 32B). All these species and those with consistently rudimentary epicortices (see below) are non-maculate.

In the western area, pruinose and non-pruinose states of *X. chalybaeizans* have been found together on the same rock face and even growing over one another. However, as their chemistries are the same and similar examples are known elsewhere, such as *Dimelaena* Norm. (Sheard, 1974; Weber, 1977), these states were treated as being conspecific.

Various types of crystals occur at the tips of some pored-epicorticate specimens of *X. chalybaeizans*, *X. perspersa*, *X. psoromifera* and X. *worcesteri* (plate 6A, C, and D), which may cause a faint pruinosity. The epicortices of X. *perspersa* and X. *worcesteri* have also been observed to be blistered at the very lobe tips (plate 6B).

Species which constantly display rudimentary epicortices are X. *colorata*, X. *heterodoxa*, X. *leptoplaca*, and X. *schenckiana*. X. *squamatica* was not examined with the SEM, but is assumed to exhibit this habit from its macroscopic appearance. The presence of a rudimentary epicortex is always indicated macroscopically by a minutely felty to coarse-pruinose upper surface. However this appearance may also be caused by a pored epicortex which is heavily embedded with crystals, as has been observed for X. *psoromifera*.

3.1.3 Cortex

Three terms pertinent to the discussion of tissue types found in the Xanthoparmeliae are used in the present work. (a) Prosoplectenchyma-fungal tissue composed of hyphae of ± elongated cells, always anticlinal in the Xanthoparmeliae, and sometimes described as palisade plectenchyma. (b) Scleroplectenchyma-fungal tissue appearing as a network of cell lumina embedded in a gelatinous matrix. This tissue type is common in thicker upper cortices, and is almost universal in the true or proper exciple. The lumina may take on an anticlinal direction (plate 7C) and grade into prosoplectenchyma. (c) Paraplectenchyma-fungal tissue composed of thin walled hyphae consisting of isodiametric cells. Not found in the Xanthoparmeliae but present in other foliose genera such as *Phaeophyscia* and *Physcia* (Moberg, 1977), *Cetraria* (Culberson and Culberson, 1968; Karnefelt, 1979) etc.

(i) The Upper Cortex

The upper cortices of all faintly and non-maculate specimens were observed (after usnic acid clearance) to be anticlinally prosoplectenchymatous, with the cells usually becoming shorter near the upper surface (plate 7A; 8A). In most of these species this stratum varies between 10 and 30 µm thick, but may be thicker (up to 60 µm) in *X. schenckiana*. An aberrant, very thick (up to 200 µm) upper cortex was found in a single specimen of *X. subconspersa*.

Maculate species show a greater upper cortex thickness variation, both within and between specimens of the same species. This is coupled to a tissue-type variation, the thicker portions being scleroplectenchymatous, and the thinner regions being the usual prosoplectenchymatous. The greatest variation has been observed in *X. exornata*, ranging from zero at some pored-epicorticate areas to about 250 µm. The upper cortex ranges between 15 and 100 µm thick in *X. columnata*, and between 15 and 70 µm in the *X. hypoleia* group and *X. leucostigma*. It is important to note that these are the maximum ranges observed for the species in question, and not all specimens of each species show this maximum variation.

(*ii*) The Lower Cortex

The lower cortices are more constant in thickness on the terminal lobes of most species, ranging from 5-15 µm. These are well differentiated from the adjacent medullae, and are composed of thick walled isodiametric cells (therefore not true paraplectenchyma; plate 8B). The stratum may become thicker towards the interior of the thallus, often with a concomitant enlargement of component cells, and a loosening of the tissue structure, which often clarifies the anticlinical arrangement of the hyphae.

The pigmentation of this layer varies from colourless to very dark brown in (15-20 µm) section. In some cases (e.g. the *X. hypoleia* group), the brown pigment is distributed around the outer walls of each cell of the component hyphae, giving the appearance of paraplectenchyma.

3.1.4 <u>The Algal Layer</u> (Plate 7A, B, and C; 8A, and C)

The algal layer is composed of trebouxoid algae in all cases. These algae commonly vary from 6-15 µm, but sometimes reach 25 µm in mean diameter. The algal layer is thinnest near the lobe tips and thickens towards the interior. Maculate species have uneven, and non-maculate species relatively even algal layers, the limits in the latter case being 20-80 µm thick.

The maculate species show great variation in thickness of this layer, both within and between specimens of the same species, and also between species. [illegible] variable is *X. exornata* in which the algal layer, basically [illegible] thick, rises to and falls away from the upper surface at intervals, resulting in vertical thicknesses of up to 400 µm. The paler areas on the obverse surface (maculae) represent the areas where: (a) the epicortex is highly pored; (b) the algal layer reaches the surface; and (c) the upper cortex is thinnest. This can be observed when suitable lobes are manually sectioned under a dissecting microscope.

The remainder of the maculate species have this layer uneven and up to 80 µm thick. A pale area on the upper surface (a macula) seems to be caused either by a break in the algal layer or a region of thin (prosoplectenchymatous) upper cortex. The thicker (scleroplectenchymatous) regions of the upper cortex are more translucent and appear darker.

3.1.5 <u>The Medulla</u> (Plate 7B; 8A)

The medulla is composed of loosely interwoven hyphae (plectenchyma) in all species. The plectenchyma may be more tightly interwoven: (a) in thinner medullae; (b) towards the lower cortices; and (c) in the stipe regions of some apothecia. The medullary hyphae are thick walled and between 3 and 7 µm, and sometimes up to 9 µm thick at swollen septa.

Many species show both normal and bone shaped septa, (as reported for *Cetrelia cetraroides* (Del. ex Duby) Culb. et Culb. by Jahns (1973)).

The medulla is very variable in thickness in most species and is the main cause for the variability in thallus thickness. In emaculate species the medulla tends to be relatively even, whereas it is more irregular in maculate species. The extreme of the latter case again being *X. exornata* with the medulla varying between 100 and 650 µm thick.

3.1.6 Isidia (Plate 23C, and D; 24 C and D)

Isidia are small corticate outgrowths on the obverse side of the thallus, incorporating algal and medullary tissue. In this collection they vary from 50-300 µm in cross section, are less than 1 mm high, and are simple to slightly branched. The shape ranges from cylindrical through clavate to almost spherical, and dorsiventral isidia are sometimes present. The isidia of *X. globulifera* (plate 23D) and *X. subramigera* (plate 24D) are coarse and clavate to spherical, often with cleanly broken-off tips. However, in this study the size and shape of the isidia were taken to be of no taxonomic significance.

In the Karoo, the isidiate Xanthoparmeliae are conspicuous in their rarity. This is one of the outstanding features of its *Xanthoparmelia* flora, in contrast with the eastern area where isidiate species are common. A similar study in Arizona (Nash, 1974a) has revealed that isidiate species of *Xanthoparmelia* are common in a region with a similar climate to the Karoo.

Two tentative examples of exisidiate-isidiate species pairs (Poelt, 1972) are present in the collection: (a) *X. subconspersa-X. subramigera*; and (b) *X. subdecipiens-X. globulifera*. The latter example is unsatisfactory in that the aliphatic acid chemistries of the pair consistently differ from each other, and the non-isidiate member is black or pale brown beneath, whereas the isidiate member is known only from specimens which are pale brown below. However, none of the aliphatic acids were positively identified.

3.1.7 Rhizines and Holdfasts

Rhizines are extensions of the lower cortex, and consist of many strands of conglutinate hyphae running parallel to their axes. They vary from 50-300 μm in thickness and from about ½ to 1½ mm long. They are frequently simple, but coarser rhizines may be sparsely branched, chiefly in the apical half. Sometimes these structures become fused together, or grade into holdfasts. Holdfasts differ from rhizines in containing medullary tissue, and range from cylindrical to variously shaped.

On the whole, rhizines are not good characters for determining species, being too variable in size and abundance. However, *X. brunnthaleri* exhibits small rhizines (about ½ mm long or less), and *X. exornata* coarse rhizines (1-1½ mm long). Unless the lobes are subascending, many species exhibit rhizines of moderate size (about ½ to 1 mm long). The incidence of rhizines is very variable in species such as the *X. hypoleia* group, *X. constrictans*, and in subascending-lobed specimens of species which show this habit, being absent or sparse to moderately abundant. Crustose to subcrustose specimens are erhizinate or have small rudimentary rhizines (plate 8A, and C). Most other species are moderately rhizinate, with the rhizines distributed unevenly on the interior of the lower surface.

3.1.8 Thallus Colour

(i) Upper Surface

All species are some shade of green or yellow-green due to the presence of the yellow pigment usnic acid in the upper 10-30 µm of the cortex.

(ii) Under Surface

A lower cortex is present in all species, at least at the lobe termini, and varies from almost white to black. The colour is caused by non-extractable brown pigments in this stratum (Melanins ?)
The brown character of black ventral cortices can be seen in section.

Species which consistently exhibit black lower surfaces are: *X. burmeisteri*, *X. columnata*, *X. constrictans*, *X. dysprosa*, *X. hypoleia*, *X. hypomelaena*, *X. hypoprotocetrarica*, *X. schenckiana* and *X. tasmanica*. Species consistently pale brown below are: *X. adhaerens*, *X. brunnthaleri*, *X. chalybaeizans*, *X. dichromatica*, *X. endomiltodes*, *X. exornata*, *X. globulifera*, *X. heterodoxa*, *X. hyporhytida*, *X. ianthina*, *X. leptoplaca*, *X. leucostigma*, *X. molliuscula*, *X. ralla*, *X. scabrosa*, *X. squamatica*, *X. subconspersa* and *X. subramigera*. Species displaying both black and pale brown under surfaces (in different specimens) are: *X. colorata*, *X. perspersa*, *X. psoromifera*, *X. subdecipiens* and *X. worcesteri*. Some of the species are known from too few individuals to permit unequivocal colour classification. The common species, *X. exornata*, is consistently pale brown on the reverse surface in the present collection, but the type is black. It is not clear whether this is atypical for this species, and more collections from the western (type) area may clarify this point. Another common species, *X. subconspersa* is basically pale underneath but may become blackened from the lobe tips inwards, until some specimens are largely black, with a small pale portion in the centre. A similar type of colour variation is suspected in *X. [illegible]orhytida.*

Among the species with variable under surface colour, *X. perspersa* and *X. worcesteri* are common. In these species the pale brown and black states predominate while only a few specimens are dark brown below. However, this colour variation could be due to a concentration effect of a single pigment, which may even be environmentally induced. It was considered best to regard these black and pale brown states as single species, until better evidence becomes available. The black and pale brown variants of *X. colorata* and *X. worcesteri* show distributional patterns, but the remaining species do not. The common (black) form of *X. colorata* occurs on the western and southern margins, but a pale form occurs in the Roggeveld and Nuweveld ranges, where the black state has not been found. The black variant of *X. worcesteri* is restricted to the western part of the Karoo, whereas the pale state is widespread. While the distribution could be invoked to regard these colour forms as separate species, the was considered inadvisable because the other species showed no definite distributional patterns related to colour.

3.2 APOTHECIA

3.2.1 Apothecial Habit

The apothecia are always laminal on the upper surface of the thallus. They vary from immersed to adnate in the crustose to subcrustose species, commonly not exceeding 1 mm and never more than 2.5 mm in diameter, and are always plane or convex (plates 33, 34, 35). Of the foliose to subfruticose species range, three deserve particular mention with regard to their apothecial habit. *X. brunnthaleri* is unusual among the foliose species in having distinctively plane apothecia, up to 5 mm in diameter, which sometimes become convex and plicate (plate 25). Deeply cupped (suburceolate) apothecia are common for *X. colorata* and *X. schenckiana* (plate 31A, and C), in contrast to those of the similar species *X. psoromifera*, which are shallowly cupped, a common condition for apothecia in this genus (plate 31D). Most apothecia of foliose specimens are substipitate but become adnate and plane on smaller-lobed specimens. The majority of apothecia have been found to be under 1 cm, but reach 2½ cm in diameter in certain species. Perforations are sometimes present, but are artifacts caused by lichen predators such as mites and curculionid beetles (c.f. *Parmotrema* Mass. p.p., Hale, 1965).

The hymenial surface colour varies from chestnut brown to black in most species, but is essentially black in *X. colorata, X. psoromifera* and *X. schenckiana*. The surface is also often finely pruinose as well, in the first and last mentioned species. Crustose and subcrustose specimens also tend to have apothecia with black hymenial surfaces. The pigmentation is present only in the upper 5-10 µm of an otherwise hyaline hymenium.

3.2.2 Apothecial Structure

The structure of the apothecium is consistent in all species except *X. heterodoxa* and *X. ralla*, which will be excluded from this discussion unless mentioned specifically. The apothecium consists of two major components: (a) the apothecium per se, or true (proper) apothecium, the reproductive structure of the lichen fungus ; and (b), the thalline exciple, (the thalline tissue surrounding this reproductive structure). The true apothecium in turn consists of three layers: the true or proper exciple; the subhymenium; and the hymenium or fertile layer (fig. 14).

unusual among the foliose species in having distinctively plane apothecia, up to 5 mm in diameter, which sometimes become convex and plicate (plate 25). Deeply cupped (suburceolate) apothecia are common for *X. colorata* and *X. schenckiana* (plate 31A, and C), in contrast to those of the similar species *X. psoromifera*, which are shallowly cupped, a common condition for apothecia in this genus (plate 31D). Most apothecia of foliose specimens are substipitate but become adnate and plane on smaller-lobed specimens. The majority of apothecia have been found to be under 1 cm, but reach 2½ cm in diameter in certain species. Perforations are sometimes present, but are artifacts caused by lichen predators such as mites and curculionid beetles (c.f. *Parmotrema* Mass. p.p., Hale, 1965).

The hymenial surface colour varies from chestnut brown to black in most species, but is essentially black in *X. colorata, X. psoromifera* and *X. schenckiana.* The surface is also often finely pruinose as well, in the first and last mentioned species. Crustose and subcrustose specimens also tend to have apothecia with black hymenial surfaces. The pigmentation is present only in the upper 5-10 µm of an otherwise hyaline hymenium.

3.2.2 Apothecial Structure

The structure of the apothecium is consistent in all species except *X. heterodoxa* and *X. ralla*, which will be excluded from this discussion unless mentioned specifically. The apothecium consists of two major components: (a) the apothecium per se, or true (proper) apothecium, the reproductive structure of the lichen fungus ; and (b), the thalline exciple, (the thalline tissue surrounding this reproductive structure). The true apothecium in turn consists of three layers: the true or proper exciple; the subhymenium; and the hymenium or fertile layer (fig. 14).

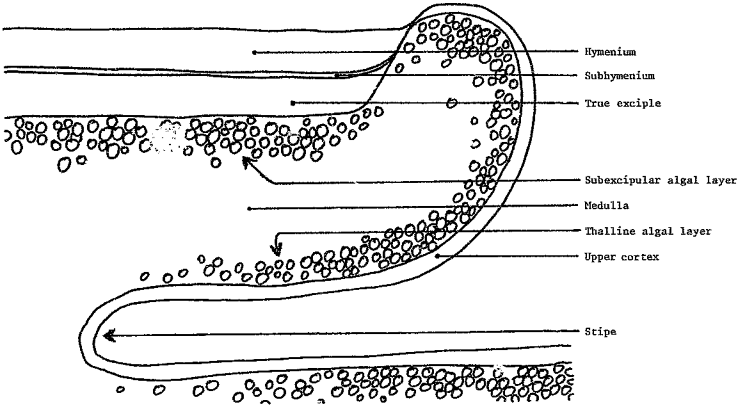


Fig. 14 Diagrammatic representation of a typical *Xanthoparmelia* apothecium in section.

The development of the apothecia of non-crustose species has been found to be angiocarpic (sensu Corner (1929)).

(i) The Thalline Exciple

This unit resembles the thallus itself, but lacks a lower cortex. Two algal layers are present: one below the obverse cortex, as in the thallus itself, and the other below the true exciple. These two layers of algae appear to arise independently as there always is a discontinuity in the radial "meristem" region of the true apothecium.

(ii) The True Exciple

This stratum is always hyaline. In all but crustose to subcrustose species or parts of species, it is horizontal and scleroplectenchymatous, varying from 20-100 µm thick. In crustose to subcrustose species, however, the exciple is thinner (10-20 µm), sometimes shallowly funnelled, and tends towards an anticlinal prosoplectenchymatous condition.

(iii) The Subhymenium

This thin layer is always 5-20 µm thick and even. It reacts pale blue with Lugol's iodine and is sometimes indiscernible from the hymenium. The subhymenia of *X. heterodoxa* and *X. ralla* are clearly conical and thicker, much thicker than the funnelled exciple.

(iv) The Hymenium

The hymenium ranges between 40 and 70 µm in thickness, and is dark blue in Lugol's iodine, especially when asci are abundant. It is composed of a mass of conglutinate paraphyses interspersed with clavate asci. In most foliose species, thin (10 µm), phloxine-stained sections *of this layer show that* the paraphyses are infrequently to rarely branched and anastomosed, becoming fairly frequently branched and *anastomosed in subcrustose forms of X. perspersa* and *X. worcesteri*. The paraphyses are thick walled, 3-8 septate, with the septa becoming more closely spaced towards the tips, which may be slightly swollen.

The asci are narrowly to broadly clavate with thick KI_3 + blue apical domes, and exhibit a rostrate mode of dehiscence (Honegger, 1978). The ascospores are commonly arranged in an indistinct bi-to triseriate fashion, but some species show an indist-inct uni- to biseriate arrangement in more narrowly clavate asci. The asci contained 8 ascospores in all observed cases. The ascospores are hyaline, unilocular, approximately ellipsoid and lack bipolar symmetry. Only one ascospore size range is present: 7-12 µm long by 4-7 µm wide (c.f. *Parmotrema* Mass., Hale, 1965; Winnem, 1975). Most ascospores are shorter than twice their breadth. The ascospore wall is ordinarily somewhat less than 1 µm thick, but may become somewhat thicker at the poles.

3.3 PYCNIA AND PYCNOCONIDIA

The pycnia of many species have been examined, and are between 50-200 µm in mean diameter. These organs are completely immersed in the *upper side of the* thallus, are narrowly to broadly flask shaped, and open to the exterior by means of ostioles which are flush with the upper surface. The ostiolar regions (plate 5D) are often, but not always, blackened, and may thus appear as black spots on the obverse surface. However many factors may cause black spots, the most common besides the presence of pycnia, is the presence of apothecial primordia. The upper surface of *X. brunnthaleri*, for example, is commonly black spotted, but most of these are apothecial primordia.

The pycnoconidia are straight or slightly curved hyaline rods, often 5-8 µm long by about 1 µm thick (plate 7D; 8D). These exhibit swellings at one to four points along their lengths, but 1 or 2 swellings are most frequent. The pycnoconidia of *X. colorata, X. schenckiana* and some subcrustose specimens of *X. perspersa* are longer (8-12 µm). The longer pycnoconidia are almost evenly rod shaped, that is the swellings, if present are not prominent.

4. TAXONOMY

4.1 HISTORICAL REVIEW OF GENERIC CONCEPTS USED FOR THE SPECIES NOW CLASSIFIED IN *XANTHOPARMELIA*

One of the best known of the very early documents on plants was written by Theophrastus (371-284 BC) of Eresis, Greece, who used the word "lichen" to signify superficial growth on the bark of olive trees. In the long period of time until de Tournefort (1694), the word "lichen" was applied more often to hepatics belonging to the Marchantiales than to lichens, and many of the latter were described as mosses. During this period no serious attempt was made to group the known plants into genera, and it was Tournefort (1694) who first did so, giving diagnoses for each of his genera. In the genus *Lichen* he included mainly lichens with a few higher cryptogams. From this date until around 1800, the genus *Lichen* was used for most foliose lichens with green algae. Although other lichens had been segregated into other genera, these were not widely accepted in the latter half of the 18th century, due to the dominance of the conservative Linnaeus. Prior to Linnaeus (1753) the generic names were used in conjunction with short sentences to designate the species, and binomials were chance occurrences. The first *Xanthoparmelia* to be described in binomial form was *X. centrifuga* (L) Hale as *Lichen centrifugus* L followed by another arctic *Xanthoparmelia*, *X. incurva* (Pers.) Hale as *Lichen incurvus* Pers. The only other *Xanthoparmelia* published as a binomial in the genus *Lichen* was *X. conspersa* (Ach.) Hale, as *L. conspersus* Ach. Towards the end of the 19th century the Linnaean dominance began to break down and attempts to separate the lichens into genera resumed. Several genera were associated with the Xanthoparmeliae around 1800, all of them imprecisely delimited purely on external morphological features and therefore all very broad in scope. Typification of some of these genera is a problem and some have fallen into disuse due to the confusion surrounding these names. *X. centrifuga* (L) Hale was placed in the new genus *Squamaria* by Hoffmann (1790) but according to Krog and Swinscow (1979) this is an illegitimate later homonym. As pointed out by the latter authors the name *Lichen* sect. *Imbricaria* Schreber (1791) was based on *Squamaria* Hoffm. and thus the lectotype of the genus *Squamaria* is the lectotype of *Imbricaria* (Schreb.) Acharius (1794). *Imbricaria* which was used for several *Xanthoparmelias* must thus be rejected. *X. incurva* (Pers.) Hale and *X. conspersa* (Ach.) Hale have been referred to *Lobaria* (Schreb.) Hoffm., but *Lichen* sect. *Lobaria* Schreber (1791) is clearly typified by *Lobaria pulmonaria* (L) Hoffm. The genus *Placodium* Wigg. has been used for *X. incurva*, because of its tightly adnate and small habit (Frege, 1812). *Placodium* Wigg. is typified by *Placodium candelarius* (L) Wiggers (1780) the basionym being *Lichen candelarius* Linnaeus (1753). *X. camtschadalis* (Ach.) Hale was originally described in *Borrera* Ach., a genus used to accommodate a diverse range of subfruticose to fruticose lichens.

Despite the handful of genera used for the then known Xanthoparmeliae, the genus *Parmelia* Ach. was predominantly used for these lichens from its inception. However, the concept of the genus was very broad, and it was not until de Notaris (1846, 1847) that the extraneous elements such as the foliose Physciaceae and Teloschistaceae were excluded. The number of newly described species in *Parmelia* (s.lat.) began increasing and the genus rapidly became large and unwieldy.

First attempts to sort the species into natural groups were by arranging the species under the name of the oldest, most well known or most typical member of the group. For example Nylander (1860) grouped most of the Xanthoparmeliae in his "Stirps *Parmelia conspersae*". Later named sections were used and Wainio (1890) in his study of Brazilian lichens, coined the name *Xanthoparmelia* as a section of his subgenus *Euparmelia*. He placed all narrow lobed yellow-green species (those containing the yellow pigment usnic acid in the upper cortex) in this section. This is now regarded as a very broad interpretation of the taxon, as greater emphasis is placed on other characters, such as cilia, rhizines and substrate ecology. Thus Wainio included *Relicina abstrusa* (Vain.) Hale, *Hypotrachyna flavida* (Zahl.) Hale, *H. velloziae* (Vain.) Hale, and *Pseudoparmelia sphaerospora* (Nyl.) Hale in his section *Xanthoparmelia*.

The epithet *Xanthoparmelia* has since been used as a section of subgenus *Euparmelia* by many authors (Zahlbrückner (1929)), but with differing delimitations and broader in concept than is presently regarded as acceptable. Hale and Kurokawa (1964) raised the taxon to the rank of subgenus retaining a narrow and refined concept. The taxon included all narrow lobed, obligately saxicolous, simply rhizinate species which contain usnic acid in the upper cortex and which are devoid of cilia and pseudocyphellae. This concept of the taxon was retained when it was raised to the rank of genus by Hale (1974d).

The generic status of the taxon is a point of contention at present as is the treatment of the whole of *Parmelia* (sensu lato) Hawksworth, 1978; Krog and Swinscow, 1979). In the present work generic status has been accorded to the taxon, because of its distinct ability to survive under semidesert conditions, and the abundant *Xanthoparmelia* cover produced under more humid conditions in comparison to the other allied genera *Pseudoparmelia* and *Neofuscelia*. [illegible] genera also show different ranges of thallus habit and mo[illegible] nuances, besides the clearer differences, such as in cortical chemistry.

4.2 KEY TO THE KAROO XANTHOPARMELIAE

1 Thallus isidiate 56
1 Thallus not isidiate 2

2 (1) Thallus foliose to fruticose 15
2 (1) Thallus subcrustose to crustose 3

3 (2) Thallus crustose, always less then 100 µm thick, medulla very thin and obscure, KC reaction obscure 4
3 (2) Thallus mostly thicker than 100 um, medulla clearly visible in oblique section, and medullary reactions clear 5

4 (3) Thallus often scattered, frequently with minute sublinear lobes present (norlobaridone in the algal layer and medulla) .... *X. ralla* Brusse
4 (3) Thallus often coherent, lobes elongate to very elongate, (evernic acid sometimes with lecanoric acid in the algal layer and medulla) .... *X. heterodoxa* (Hale) Hale

5 (3) Medulla K+ yellow to blood-red 6
5 (3) Medulla K-, P- 12

6 (5) Medulla K+ pale yellow (perhaps better regarded as K-) may become a dingy colour on drying, P- 7
6 (5) Medulla K+ yellow to blood-red, P+ yellow to orange 8

7 (6) Medulla K+ pale yellow, KC-, very strongly blue white fluorescent in longwave ultraviolet light (squamatic acid present) .... *X. squamatica* Brusse

7 (6) Medulla K+ pale yellow sometimes drying to a pale violet colour, KC+ rose to orange rose to sometimes red, weakly to strongly blue-white fluorescent in longwave ultraviolet light (hypoprotocetraric acid, 4-O-demethylnotatic acid and associates present) .... *X. perspersa* (Stiz.) Brusse

8 (6) Medulla K+ yellow sometimes becoming orange (stictic acid and associates present) 9

8 (6) Medulla K+ yellow becoming red or blood-red, or yellow-orange often becoming blood-red 10

9 (8) Upper surface pruinose to dull, undersurface pale, lobes elongate to very elongate, apothecia sometimes immersed .. .. *X. adhaerens* (Nyl.) Hale

9 (8) Upper surface dull to glossy, undersurface black on the most interior exposable surface, lobes sometimes sublinear, apothecia not immersed .... *X. constrictans* (Nyl.) Hale

10 (8) Medulla K+ yellow-orange often becoming orange, red or blood-red (salazinic acid with the "chalybaeizans unknown" present) .... *X. chalybaeizans* (J. Stein. et Zahlbr.) Hale

10 (8) Medulla K+ yellow becoming red or blood-red (salazinic acid present) 11

11 (10) Upper surface pruinose to minutely felty, undersurface pale, lobes elongate to very elongate, apothecia often immersed .... *X. leptoplaca* (Zahlbr.) Brusse

11(10) Upper surface dull to glossy, undersurface black or the most interior exposable surface, lobes sometimes sublinear, ... *X. constrictans* (Nyl.) Hale

12 (5) Medulla C+ citrine yellow to red 13

12 (5) Medulla C- 14

13(12) Medulla C+ red, KC+ red (lecanoric acid present) .... *X. worcesteri* (J. Stein. et Zahlbr.) Hale

13(12) Medulla C+ citrine yellow, sometimes with an initial fleeting C+ yellow or even orange reaction, KC+ rose to rose-orange (hypoprotocetraric acid, 4-O-demethylnotatic acid and associates present .. *X. persperea* (Stiz.) Brusse

14(12) Medulla KC+ rose to orange, weakly to strongly blue-white fluorescent in longwave ultraviolet light (hypoprotocetraric, 4-O-demethylnotatic acids and associates present) .... *X. persperea* (Stiz.) Brusse

14(12) Medulla KC-, very strongly blue-white fluorescent in longwave ultraviolet light (squamatic acid present) .... *X. squamatica* Brusse

15 (2) Upper surface faintly to coarsely maculate, dull to glossy, never minutely felty or coarse-pruinose 43

15 (2) Upper surface non-maculate, glossy, dull, minutely felty or coarse-pruinose 16

16(15) Undersurface black 17

16(15) Undersurface pale 30

17(16) Lobes 3-6 mm broad 18
17(16) Lobes less than 4 mm broad 23

18(17) Lobes uniformly closely appressed, upper surface dull to coarse-pruinose 20
18(17) Lobes subascending to ascending, upper surface dull to glossy 19

19(18) Medulla K+ yellow then red or blood-red or K+ yellow-orange often becoming orange, red or blood-red, P+ yellow becoming orange (salazinic acid with or without the "chalybaeizans unknown") .. *X. hyporhytida* (Hale) Hale
19(18) Medulla K- then very slowly becoming dingy orange or red, P+ yellow becoming red or blood-red; or K-, KC+ rose, P+ yellow becoming orange or orange-red (protocetraric, fumarprotocetraric and succinoprotocetraric acids and associates present) .... *X. subconspersa* (Nyl.) Hale

20(18) Medulla K+ yellow then red to blood-red (salazinic acid present) .... *X. colorata* (Gyel.) Hale
20(18) Medulla K- or K+ pale yellow 21

21(20) Medulla P-, often C+ pale citrine yellow sometimes with an initial fleeting yellow or even orange, KC+ rose to *orange-rose* .... *X. persparsa* (Stiz.) Brusse
21(20) Medulla P+ yellow to red 22

22(21) Medulla P+ pale yellow becoming rich citrine yellow or golden yellow, KC- (Psoromic acid and 2'-O-demethyl-psoromic acid present) ...... *X. psoromifera* (Kurok.) Hale

22(21) Medulla P+ yellow becoming orange to red, KC+ rose (protocetraric acid present) .... *X. schenckiana* (Müll. Arg.) Hale

23(17) Medulla K+ yellow to blood-red 24

23(17) Medulla K- 28

24(23) Medulla K+ yellow sometimes becoming orange (stictic acid and associates present) 25

24(23) Medulla K+ yellow becoming red or blood-red (salazinic acid present) or K+ yellow-orange often becoming red to blood-red (salazinic acid and the "chalybaeizans unknown" present) 26

25(24) Lobes always less than 2 mm broad, often constricted and constrictions more conspicuous on broader lobes. Thallus uniformly tightly adnate to loosely adnate and "stenophylloid" .... *X. constrictans* (Nyl.) Hale

25(24) Lobes prominently broader than 2 mm .... *X. hypopsila* (Müll. Arg.) Hale

26(24) Undersurface black except in the centre of the thallus or near the bases of lobes. Medulla K+ yellow or yellow-orange, becoming red or blood-red. Thallus loosely adnate with sublinear to linear lobes, sometimes with a normally foliose circumference (salazinic acid with or without the "chalybaeizans unknown" present) .... *X. hyporhytida* (Hale) Hale

26(24) Undersurface completely black, except at the lobe tips, medulla K+ yellow becoming blood-red (salazinic acid present) 27

27(26) Lobes always less than 2 mm broad, often constricted, constrictions more conspicuous on broader lobes. Thallus uniformly tightly adnate to loosely adnate and "stenophylloid" .... *X. constrictans* (Nyl.) Hale

27(26) Lobes commonly 2-4 mm broad, if prominently less than 2 mm broad, then not conspicuously constricted, and some lobes broader than 2 mm. Thallus moderately to loosely adnate . ... *X. tasmanica (Hook.f.et Tayl.) Hale*

28(23) Medulla C+ red, KC+ red (lecanoric acid present) .... *X. worcesteri* (J. Stein. et Zahlbr.) Hale

28(23) Medulla C- or C+ citrine yellow 29

29(28) Medulla KC+ rose to orange-rose, C+ pale citrine yellow, sometimes with an initial fleeting yellow to orange colour (hypoprotocetraric acid, 4-O-demethylnotatic acid and associates present) .... *X. persparsa* (Stiz.) Brusse

29(28) Medulla KC-, C- (aliphatic acids present) .... *X. subdecipiens* (Vain. ex Lynge) Hale

30(16) Maroon to violet pigments present in the medulla, sometimes only as spots 31

30(16) Medulla without maroon to violet pigments 33

31(30) Medulla spotted with maroon to violet pigments, P+ yellow becoming orange to red, KC+ rose (protocetraric acid, with one to all of the "endomiltodes unknowns" present) .. .. *X. dichromatica* (Hale) Hale

31(30) Medulla completely maroon to violet, or with the lower part of the medulla white 32

32(31) Medulla containing salazinic acid and all of the "endomiltodes unknowns" .... *X. endomiltodes* (Nyl.) Hale

32(31) Medulla containing Th-1, Th-2 and all of the "endomiltodes unknowns" .... *X. ianthina* Brusse

33(30) Thallus foliose to fruticose, with varying proportions of terete lobes (upper cortex continuous all the way around the circumference) and dorsiventral lobes. Medulla K+ yellow sometimes becoming orange (stictic acid and associates present) .... *X. molliuscula* (Ach.) Hale

33(30) Thallus foliose to subfruticose, terete lobes absent 34

34(33) Medulla K+ yellow to blood-red 35

34(33) Medulla K- or K - then a slow dingy orange or red 37

35(34) Medulla K+ bright yellow becoming bright orange, C-, KC no effect or bleaching the K reaction slightly, P+ yellow then red to blood-red (4-O-methylhypoprotocetraric acid, FB-1 and FB-2 present .... *X. perspersa* (Stiz.) Brusse

35(34) Medulla K+ yellow becoming red or blood-red, or K+ yellow-orange often becoming red to blood-red, P+ yellow becoming orange 36

36(35) Thallus lobes prominently 4-6 mm broad, upper surface felty to coarse-pruinose, medulla K+ yellow then red (salazinic acid present) .... *X. colorata* (Gyel.) Hale

36(35) Thallus lobes very variable, prominently 1-4 mm broad; upper surface commonly dull to glossy, but becoming minutely felty to coarse pruinose in the NW area. (salazinic acid and the "chalybaeizans unknown" present) .... *X. chalybaeizans* (J. Stein. et Zahlbr.) Hale

37(34) Medulla P+ citrine yellow to blood-red 38

37(34) Medulla P- 39

38(37) Medulla K- then a slow dingy orange or reddish, P+ yellow becoming red or blood-red; or K-, KC+ rose, P+ yellow becoming orange to red (protocetraric, succinoprotocetraric, fumarprotocetraric acids and associates present). Thallus often moderately to loosely adnate .... *X. subconspersa* [illegible]) Hale

38(37) Medulla K-, P+ pale citrine yellow becoming citrine yellow to golden yellow (Psoromic and 2'-O-demethylpsoromic acids present). Thallus tightly adnate often uniformly closely appressed, lobes prominently 3-6 mm broad .... *X. psoromifera* (Kurok.) Hale

39(37) Medulla C+ red, KC+ red (lecanoric acid present) .... *X. worcesteri* (J. Stein. et Zahlbr.) Hale

39(37) Medulla C- or C+ pale citrine yellow or pale orange 40

40(39) Medulla KC+ rose to orange 41

40(39) Medulla KC- (C-, P-) 42

41(40) Medulla K+ pale yellow sometimes drying pinkish or pale violet, C+ pale citrine yellow, sometimes with an initial fleeting yellow to orange reaction, KC+ rose to orange (hypoprotocetraric, 4-O-demethylnotatic acids, and associates present) ...... *X. persparsa* (Stiz.) Brusse

41(40) Medulla K-, C- or C+ pale yellow to pale orange, KC+ faint rose to orange-red (barbatic, 4-O-demethylbarbatic acids and several associates present) .... *X. brunnthaleri* (J. Stein. et Zahlbr.) Hale

42(40) Thallus tightly adnate, lobes prominently 2-4 mm broad, if narrower then thallus adnate to loosely adnate (aliphatic acids present) .... *X. subdecipiens* (Vain. ex Lynge) Hale

42(40) Thallus tightly adnate, lobes prominently 1-2½ mm broad, always uniformly closely appressed, often contiguous and very elongate (brun-1, brun-2 and brun-3 present) .... *X. brunnthaleri* (J. Stein. et Zahlbr.) Hale

43(15) Undersurface black 50

43(15) Undersurface ivory to brown 44

44(43) Medulla K+ yellow to blood-red 47

44(43) Medulla K-, or K- then slowly becoming a dingy orange to red colour 45

45(44) Medulla P+ yellow becoming orange to blood red, K- then slowly becoming dingy yellow to dingy red, KC-; or K- and KC+ rose (protocetraric, succinoprotoectraric, fumarprotocetraric acids and associates present), upper surface faintly maculate only .... *X. subconspersa* (Nyl.) Hale

45(44) Medulla P–, upper surface distinctly maculate 46

46(45) Medulla C– or C+ pale rose, KC+ rose (gyrophoric acid present) .... *X. leucostigma* Brusse

46(45) Medulla C–, KC– (no substances present) .... *X. exornata* (Zahlbr.) Brusse

47(44) Thallus "stenophylloid" (i.e. loosely adnate, and composed of highly imbricated, sublinear to linear lobes) 49

47(44) Thallus normally foliose or composed of discrete, evenly appressed convex lobes 48

48(47) Lobes discrete, evenly appressed, convex and thick; to flat and thick. Maculae coarse but may become largely confluent. (Medulla containing salazinic acid with or without the chalybaeizans unknown) .... *X. exornata* (Zahlbr.) Brusse

48(47) Thallus normally foliose, lobes thin, maculae faint. (Salazinic acid and the "chalybaeizans unknown" always present in the medulla .... *X. chalybaeizans* (J. Stein. et Zahlbr.) Hale

49(47) Lobes thin and flat, upper surface faintly maculate .... *X. hyporhytida* (Hale) Hale

49(47) Lobes thick and convex, upper surface distinctly to faintly maculate (by confluence) ...... *X. exornata* (Zahlbr.) Hale

50(43) Thallus composed of discrete, evenly appressed, very elongate to sublinear convex lobes 51

50(43) Thallus not as above 52

51(50) Medulla K+ yellow or orange-yellow, becoming red to blood-red, C-, KC no change or bleach, P+ slowly yellow to yellow-orange to orange-red. (Salazinic acid with or without the "chalybaeizans unknown" present) .... *X. exornata* (Zahlbr.) Brusse

51(50) Medulla K+ pale wine rose, C+ pale citrine yellow, KC no change on the K reaction, P- (hypoprotocetraric and 4-O-methylhypoprotocetraric acids present) .... *X. columnata* Hale

52(50) Medulla either K+ pale yellow rapidly becoming bright orange to bright orange-red and P+ citrine yellow, or K+ rich citrine yellow becoming orange-yellow on drying and P+ citrine yellow slowly becoming yellow-orange (Th-1 and associates, or thamnolic acid present). Upper surface strongly to more often weakly maculate .... *X. hypomelaena* (Vain. ex Lynge) Brusse

52(50) Medulla K- or K+ pale wine rose 53

53(52) Medulla P+ yellow becoming orange to orange-red (protocetraric and virensic acids present) .... *X. hypoleia* (Nyl.) Hale

53(52) Medulla P- 54

54(53) Medulla faint pink, K+ pale wine rose, KC no change or slight darkening, C+ pale citrine yellow (hypoprotocetraric and 4-O-methylhypoprotocetraric acids present) .... *X. hypoprotocetrarica* (Kurok. et Elix) Hale

54(53) Medulla K-, KC+ wine rose to bright orange, C- 55

55(54) Medulla KC+ pale wine rose to pale orange (evernic acid present) .... *X. dysprosa* Brusse

55(54) Medulla KC+ bright orange (barbatic and 4-O-demethylbarbatic acids present) ..... *X. burmeisteri* (Elix) Brusse

THALLUS ISIDIATE

56 (1) Undersurface black, medulla K+ yellow sometimes becoming orange (stictic acid and associates present) .... *X. conspersa* (Ach.) Hale

56 (1) Undersurface pale 57

57(56) Medulla P+ yellow becoming red to blood-red (Succinoprotocetraric acid and associates present) .... *X. ramigera* (Gyel.) Hale

57(56) Medulla P- 58

58(57) Medulla KC+ rose to red (norlobaridone present) .... *X. scabrosa* (Tayl.) Hale

58(57) Medulla KC- (aliphatic acids present) .... *X. globulifera* (Kurok. et Filson) Brusse

4.3 TAXONOMIC SECTION

Xanthoparmelia adhaerens (Nyl.) Hale

Plate 34 A, B, and C; Fig. 22. (p. 171).

Hale (1974) Phytologia, 28 (5): 486.

Parmelia adhaerens Nylander apud Crombie (1876) Journ. Bot. Brit. and For., 14: 19. Holotypus: Table Mountain, Cape of Good Hope, A.E. Eaton "Venus Transit Expedition, September 1874, BM!, Isotypes, BM!

Parmelia saxeti Stizenberger (1890) Ber. Thätigk. St. Gall. naturwiss. Gesellsch., 1888/89: 153. Holotypus: Supra saxa basaltica montis Lubombo in Transvaalia : Wilms, ZT.

Thallus subcrustose to crustose on rock; up to 4½ cm in diameter; lobate marginally and areolate in the centre. Lobes elongate; very closely appressed to flush with the substrate; 0.3-1.0 mm broad; up to 4 mm long to the first complete transverse fissure; 60-200 µm thick, occasionally up to 500 µm in some central bullate areoles (plate 34A). Upper surface yellow-green, but commonly darkening to olive green in the central, areolate portions of the thallus; dull to minutely felty, becoming coarse-pruinose at some lobe tips; with the epicortex highly pored to rudimentary; not isidiate or sorediate. Undersurface present at the lobe tips, but may be largely absent in the interior of the thallus; tan to creme, but difficult to observe; with rhizines rudimentary if present.

Apothecia innate to adnate; up to 0.7 mm across; plane. Ascospores (few seen) 9-13 µm by 5-6·5 µm. Pycnia 50-100 µm in mean diameter. Pycnoconidia 5-8 µm long.

Medulla white or very pale pink; K+ yellow, sometimes becoming pale orange on drying; KC no change, or bleaching the initial K reaction; C−; P+ pale orange.

Chemistry:- Usnic acid, and sometimes atranorin in the upper cortex; stictic and constictic (4-O-methylsalazinic) acids in the medulla, with norstictic and hypostictic acids, and St-1 and PQ-4 as accessory substances.

This species is probably more characteristic of the eastern half of the country than the Cape Province, where it occurs at wetter localities. It is present all along the southern margin and has been collected as far north as Clanwilliam on the western margin.

Some specimens of this species are rather difficult to separate from subcrustose forms of the stictic acid strain of *X. constrictans*. However, the lobe tips may be coarse pruinose above and are some pale shade of brown below, in the former species, and are usually glossy above and black below, in the latter species. In addition, thalli of *X. constrictans* show signs of sublinear to linear lobes, and may sometimes tend to brown in the interior.

X. adhaerens is morphologically closely related to *X. leptoplaca*, but differs in chemistry and an almost mutually exclusive distribution. Both are loosely reminiscent of *Dimelaena oriena* (Ach.) Norm. (*Physciaceae*).

Specimens examined: 3218BB, 11 km NE of Clanwilliam, Pakhuis Pass, alt. 610-670 m, 772 8-3-2 (on TMS), 772 8-3-3 (on coarse grained granitic rock); 3321AD, Seven Weeks Poort near Ladismith, on TMS, alt. 915-945 m, 772 11-3-2pp, 772 11-3-5pp, 772 11-3-6pp, 772 11-3-25, 772 11-3-37; 3322AC, 18 km S of Prince Albert, top of Swartberg Pass, alt. 1700 m, 772 11-1-2, 772 11-1-3, 772 11-1-14 (on TMS), 772 -1-9 (on coarse grained granitic rock); 3323AB, 14 km N of Willowmore, Perdepoort, on Witteberg siltstone, alt. 850-880 m, 772 14-3-7.

Xanthoparmelia brunnthaleri (J. Stein. et Zahlbr.) Hale

Plate 25; Fig. 15. (p. 128)

Hale (1974) Phytologia, 28 (5): 486.

Parmelia brunnthaleri J. Steiner et Zahlbrückner apud Zahlbrückner (1926) Bot. Jahrb. Syst. Pflanzengesch. Pflanzengeogr., 60: 505-506. Holotypus: Kapland, Matjesfontein, grosse Karroo, Sandsteinfelsen, 950 m Leg. J.Brunnthaler, 10.11.1909. W(1931) 8368!

Parmelia barbatica Elix (1976) Aust. J. Bot., 24: 633-634, Fig. 1. Holotypus: On sandstone rocks, Kowen forest, A.C.T., 18 km E of Canberra, 730 m, J.A. Elix 1389. (MEL 1015396; isotypi in CANB).

Thallus foliose; very tightly adnate; up to 5 cm across; moribund, absent, or with a secondary thallus, in the centre of large (up to 11 cm) individuals; may cover larger areas by confluence with other thalli. Lobes elongate to very elongate; closely and evenly appressed; 0.5 to 3.5 mm, but commonly 1-2.5 mm broad; 80-200 µm thick; contiguous or discrete; transversely cracked, giving rise to a pseudoareolate interior. Upper surface glossy becoming dull in the interior; pored epicorticate; non-isidiate, esorediate and emaculate. Upper cortex 25-35 µm. Algal layer 20-50 µm. Medulla 30-100 µm. Lower cortex 10-15 µm. Ventral surface tan to ivory in colour; moderately rhizinate; with rhizines mostly small.

Apothecia frequent; when present, moderately to very abundant; adnate; up to 5 mm across; flat to convex, sometimes highly folded. Hymenium 50-60 µm. Subhymenium 5-20 µm. Exciple 15-40 µm. Ascospores 8 per ascus, 6.5-11.0 by 4.5-7.0 µm (289/8). Pycnia 50-150 µm in mean diameter. Pycnoconidia 5-8 µm long.

Medulla white; K-; C-, or + pale orange or rose; KC-, or + faint to pale orange-rose to orange; P-.

Chemistry:- Usnic acid in the upper cortex, barbatic and 4-O-demethylbarbatic acids with several unknown β-orcinol depsides, and two *substances of unknown class, brun-1* and *brun-2* in the medulla.

A large number of specimens contain either the unknowns brun-1, brun-2, or β-orcinol depsides and have been regarded as two separate taxa. The discovery that all specimens of this morphological type collected at Graanaatboskolk contain both brun-1, brun-2, and unidentified β-orcinol depsides, has made it necessary to regard this assemblage as one species. The distribution of the two classes of lichen substances within this assemblage is essentially the same, both being very abundant north of the Nuweveldberg-Sneeuwberg escarpment. The type strain (those containing brun-1, brun-2 and traces of brun-3, although no substances were found in the medulla of the holotype) came from drier sites and more exposed aspects, and was less abundant and *slightly more widespread than the strain* containing β-orcinol depsides (Fig. 15). The species appears to be present in Australia as well (*Parmelia barbatica* Elix), but no specimens have been seen from that continent.

Specimens examined: (Specimens marked with * contain unknowns brun-1, brun-2 and brun-3. The remainder contain β-orcinol depsides only, except the specimens from near Graanaatboskolk).

2818AA, 37 km SW of Grünow, 772 2-2-1 *; 2819DC, 38 km NE of Pofadder, on dolerite, alt. 920-1060 m, 768 9-2-3 *; 2821CC, 29 km SSE of Keimoes, Piet Rooisberg, on pink granite, alt. 940-1040 m, 768 8-5-2, 768 8-5-3, 768 8-5-4; 2919BC, 32 km SSE of Pofadder, Steenkampsvlei ridge, on quartz, alt. 1040-1050 m, 768 9-4-4; 2919DD, 8 km NE of *Graanaatboskolk, on dolerite, alt.* 900-1060 m, 772 3-3-1, 772 3-3-2,

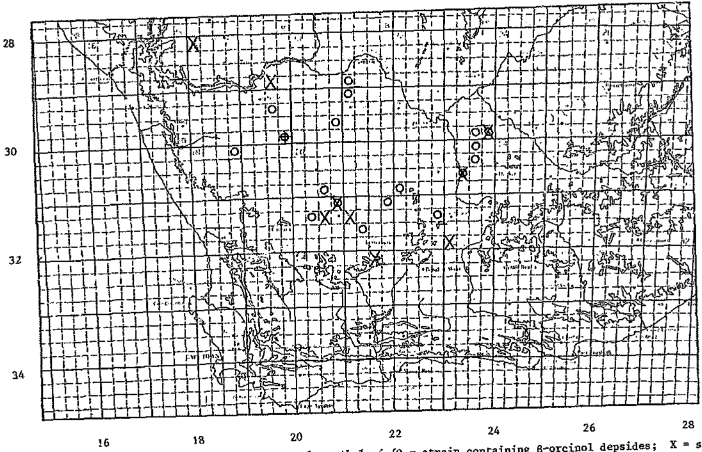


Fig. 15 Distribution of *Xanthoparmelia brunnthaleri* (O = strain containing β-orcinol depsides; X = strain containing unknown substances; ⊕ = strain containing both)

772 3-3-3, 772 3-3-4; 2920DB, 64 km SW of Kenhardt, on dolerite, alt. 880-900 m, 768 8-1-2; 2921AA, 24 km N of Kenhardt, N'Rougasberg, on quartzo-felspathic rock, alt. 850-880 m, 768 8-4-2, 768 8-4-4; 2923DC, Strydenberg, on dolerite, alt. 1080-1110 m, 768 5-2-1, 768 5-2-3, 768 5-2-5pp, 768 5-2-8pp; 2923DD, 19 km NE of Strydenburg, Elands berg, on dolerite, alt. 1190-1280 m, 768 5-1-1 *, 768 5-1-7 *, 768 5-1-8, 768 5-1-9, 768 5-1-10, 768 5-1-14, 768 5-1-15, 768 5-1-16 *, 768 5-1-17, 768 5-1-18 *; 3018BB, 59 km N of Kliprand, on a stone derived from Dwyka diamictite, alt. 920-1060 m, 768 9-5-1; 3020DC, 62 km NW of Williston, on dolerite, alt. 920-1000 m, 768 7-6-2; 3022CC, 24 km NNW of Carnarvon, on dolerite, alt. 1130-1170 m, 772 16-2-1, 772 16-2-2; 3022CC, 8 km N of Carnarvon, on dolerite, alt. 1200-1250 m, 772 16-1-2; 3023BA, 22 km S of Strydenburg, on dolerite, alt. 1000-1200 m, 768 5-3-3; 3023BC, 16 km NNE of Britstown, on dolerite, alt. 1160-1190 m, 768 5-5-1, 768 5-5-4; 3023CB, 6 km W of Britstown, on dolerite, alt. 1150-1160 m, 768 6-1-1, 768 6-1-3, 768 6-1-5 *, 768 6-1-6; 3120AD, 64 km E of Calvinia (53 km W of Williston), on dolerite, alt. 1000-1100 m, 772 10-1-1, 772 10 -2; 3120BB, 24 km NW of Williston, on dolerite, alt. 1000-1200 m, 768 7-5-1, 768 7-5-2 *; 3120BC, 34 km W of Williston, Jan Swartsberge, on dolerite, alt. 1170-1200 m, 772 10-2-3 *; 3121AC, *13 km ENE of Williston*, Soutpanspoort, on dolerite, alt. 1160-1170 m, 768 7-4-2 *; 3121BB, 40 km WSW of Carnarvon, Klipheuvels, on dolerite, alt. 1310-1330 m, 768 7-2-3; 3121CB, 27 km NW of Fraserburg, Blydevooruitzicht, on Beaufort mudstone, *alt. 1250-1265* m, 772 10-3-5, 772 10-3-7; 3122BD, 27 km W of Victoria West, Gap Kop, on dolerite, alt. 1350-1400 m, 772 15-3-1, 772 15-3-2; 3123CC, Three Sisters, on dolerite, alt. 1140-1240 m, 768 12-4-9* (N. facing slope); 3221BA, 16 km SSE of Fraserburg, Zaai Klipheuvels, on dolerite, alt. 1400-1430 m, 772 10-4-3*.

Xanthoparmelia burmeisteri (Elix) comb. nov.

Plate 17A and B; Fig. 20. (p. 161).

Basionomen: *Parmelia burmeisteri* Elix (1976) Aust. J. Bot., 24: 664-665.

Holotypus: On granite rocks, along Snowy Mountains Hwy., NSW, 10 km S of Nimmitabel, 1156 m, J.A. Elix 1613 (MEL 1015395. Isotypus: CANB).

Thallus as in *X. hypoleia* (Nyl.) Hale.

Medulla K-; KC+ bright orange; C-; P-.

Chemistry:- Usnic, barbatic and 4-O-demethylbarbatic acids.

This species is known only from a single specimen collected at Seven Weeks Poort. It is one of (at least?) two species of the *X. hypoleia* group which occur in SE Australia and the Cape. The other, *X. hypoprotocetrarica*, contains the corresponding depsidones hypoprotocetraric and 4-O-methylhypoprotocetraric acids. *X. burmeisteri* differs from other members of this group primarily in chemistry.

Specimens examined: 3321AD, Seven Weeks Poort near Ladismith, on TMS, alt. 915-945 m, 772 11-3-18a.

Xanthoparmelia chalybaeizans (J. Stein. et Zahlbr.) Hale

Plate 20; 32A, B, and D; 36 A; Fig. 16. (p. 134).

Hale (1974) Phytologia, 28 (5): 486.

Parmelia schenckiana var *chalybaeizans* J. Steiner et Zahlbrückner apud Zahlbrückner (1926) Bot. Jahrb. Syst. Pflanzengesch. Pflanzengeogr., 60: 510.

Holotypus: Kapland, Matjesfontein, grosse Karroo, sand stein, c 900-950 m, leg. J. Brunnthaler, 10/11/1909. (W. (1931) 8422!)

Parmelia chalybaeizans (J. Stein. et Zahlbr.) Gyelnik (1936)
Ann. Mus. Natn. Hungarici, 30: 127-128.
Parmelia schreuderiana Gyelnik (1938) Sydowia Ann. Mycol., 36(4): 270.
Holotypus: South Africa, Lokenburg, on stone P.A. v.d. Bijl 1197. (W (1935)-!)
Parmelia conspersula f. *chalybaeizans* (J. Stein. et Zahlbr.) Gyelnik (1938). Ann. Mus. Natn. Hungarici, 31: 24.

Thallus foliose to subcrustose; tightly adnate on rock, to rather loosely adnate on rock, soil or other thalli; up to 6 cm diameter. Lobes elongate to very elongate; contiguous to imbricate; ½ to 4 mm broad; 90-300 µm thick. Upper surface green to yellow-green becoming olive green, grey-green (glaucous) and sometimes steel-grey to brown-grey in the interior; glossy, dull, minutely felty or coarse pruinose; with the epicortex pored to rudimentary; non-isidiate, non-sorediate and faintly- to emaculate. Upper cortex 15-30 µm. Algal layer 20-40 µm. Medulla 40-200 µm. Lower cortex 8-15 µm. Lower surface: consistently pale tan to tan, but chestnut brown to black at the lobe tips; moderately rhizinate.

Apothecia frequent; when present, sparse to common; adnate to substipitate; up to 8 mm across; shallowly cupped, to plane by radial fissuring. Hymenium 40-60 µm, subhymenium 5-20 µm, exciple 30-70 µm. Ascospores 8 per ascus, 6.5-11.0 µm by 4-7 µm (120/5). Pycnia 100 to 200 µm in mean diameter. Pycnoconidia 6-8 µm long.

Medulla off-white or pale pink to rather distinctly dirty yellow, darkening with age and sometimes dirty orange on dead or damaged portions of thalli; K+ variable (Specimens with small amounts of the "chalybaeizans unknown" tend to have faint pink medullae which are K+ yellow becoming blood-red and even darker. Specimens with small amounts of salazinic acid and large amounts of the "chalybaeizans unknown" have pale dirty yellow medullae which give a K+ immediate rich yellow to yellow-orange reaction which becomes orange in 1-2 minutes. Many specimens contain appreciable amounts of both substances, and give a K+ rich yellow to yellow-orange becoming blood-red reaction in the medulla); C−; P+ orange to red.

Chemistry:- Usnic acid, sometimes with atranorin in the upper cortex; varying relative concentrations of salazinic acid and the "chalybaeizans unknown", and small amounts of norstictic acid sporadically present in the medulla. In addition some specimens contain the orange pigment skyrin in the medulla adjacent to the lower cortex, which reacts K+ dirty mauve.

This is a very variable species in the north western area of the Karoo. Two different states have been found to grow over each other on the same rock (772 9-2-19), and this bewildering array of morphological forms is difficult to treat in a taxonomically satisfactory way. The most common variant is normally foliose, glossy to dull on the upper surface, and usually moderately adnate on rock. This widespread variant occurs with a tightly adnate, foliose state which is coarse pruinose on the upper surface (plate 32B), and with a subcrustose form (plate 36A) in the north western area.

The typical variant may be confused with *X. taractica* (Kremp.) Hale, a similar species with a pale undersurface and salazinic acid in the medulla, but clearly differs from the latter, by containing the "chalybaeizans unknown" in addition to salazinic acid. *X. taractica* can thus be regarded as absent from the study area.

The subcrustose form differs from *X. leptoplaca*, which it resembles, by the presence of the "chalybaeizans unknown" in the medulla. The uncommon but characteristic steel-grey colour on the interior of *X. chalybaeizans*, is sometimes also present on subcrustose forms, and has not been observed for *X. leptoplaca*.

Some faintly maculate specimens may be assigned to *X. exornata*, but this species has thicker lobes, and a different range of habits.

A similar species is *Pseudoparmelia condyloides* (Kurok.) Hale, both containing salazinic acid and the "chalybaeizans unknown" in their medullae, but differing in their cortical chemistry. *Ps. condyloides* contains atranorin without usnic acid (although traces of usnic acid are difficult to detect with the TLC procedure used) and *X. chalybaeizans* contains usnic acid with atranorin as an uncommon accessory substance. The former is much less common than the latter species and is probably not related.

Specimens examined: 2821CC, 29 km SSE of Keimoes, Piet Rooisberg, on pink granite, alt. 940-1040 m, 768 8-5-5; 2917BD, 29 km N or Springbok, Vrieskloofhoogte/Ratelpoort, on white gneiss, 880-940 m elev., 772 2-4-14, 772 2-4-21, 772 2-4-24; 2919AC, 40 km SW of Pofadder, Achab se berge (Part of the Namiesberge), on quartzo-felspathic rock, alt. 960-1040 m, 772 3-2-11; 3017BD, 19 km S of Kamieskroon, Garagams/Karkams, on granite, alt. 760-790 m, 772 9-2-1A, 772 9-2-2, 772 9-2-4, 772 9-2-5pp, 772 9-2-6, 772 9-2-7, 772 9-2-12, 772 9-2-15, 772 9-2-19pp, 772 9-2-20; 3018CA, 20 km SSE of Garies, on gneiss, alt. 360-380, 772 9-1-4, 772 9-1-6pp, 772 9-1-7, 772 9-1-8, 772 9-1-10, 772 9-1-19; 3019CD, 6 km S of Loeriesfontein, Kubiskouberg, on dolerite, alt. 880-900 m, 772 3-4-2pp, 772 3-4-4, 772 3-4-6, 772 3-4-9, 772 3-4-13, 772 2-3-23, 772 3-4-27, 772 3-4-29pp; 3119AC, 45 km NE of Vanrhynsdorp, top of Vanrhyns Pass, on TMS, alt. 800 m, 768 10-2-11, 768 10-2-14pp, 768 10-2-19pp, 768 10-2-20, 768 10-2-21pp, 772 9-3-4, 772 9-3-6; 3119AC, 42 km NE of Vanrhynsdorp, half way up Vanrhyns Pass, on TMS, alt 460-610 m, 768 10-1-4, 768 10-1-12, 768 10-1-13; 3119CA, South Africa, Lokenburg, Calvinia, on stone,

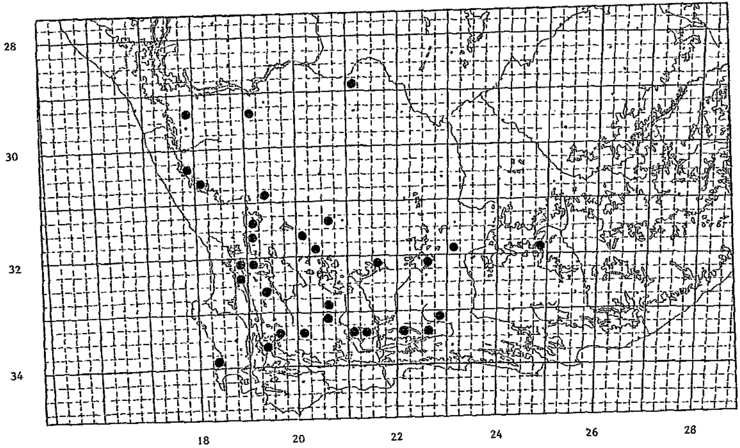


Fig. 16 The distribution of *Xanthoparmelia chalybaeizans*

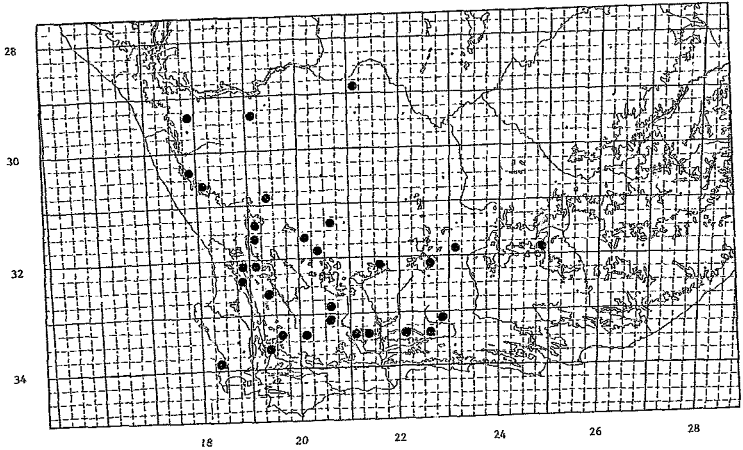


Fig. 16 The distribution of *Xanthoparmelia chalybaeizans*

P.A. v.d. Bijl 1197, W (1934)-; 3120BC, 34 km W of Williston, Jan Swartsberg, on dolerite, alt. 1170-1200 m, 772 10-2-8; 3120CA, 48 km NW of Middelpos, on dolerite, alt. 915-1220 m, 772 4-1-5pp, 772 4-1-8, 772 4-1-10pp, 772 4-1-12pp; 3120CD, 12 km ESE of Middelpos, on Beaufort mudstone, alt. 1250-1280 m, 772 4-2-7, 772 4-2-17pp (epithallic), 772 4-2-18, 772 4-2-19, 772 4-2-23pp, 772 4-2-24; 3123CC, Three Sisters, on dolerite, alt. 1140-1240 m, 768 12-4-1pp; 3124DD, Lootsberg Pass, half way between Graaff-Reinet and Middelburg, on Beaufort mudstone, alt. 1800 m, 772 15-2-17; 3218BB, 11 km NE of Clanwilliam, Pakuis Pass, on TMS, alt. 610-670 m, 772 8-3-1pp, 772 8-3-3, 772 8-3-21; 3218BD, 26 km S of Clanwilliam, Olifants river valley, on TMS, alt. 400-600 m, 772 8-1-1pp, 772 8-1-8pp, 772 8-1-13, 772 8-1-16, 772 8-1-18pp; 3219AA, 20 km ENE of Clanwilliam, top of Pakhuis Pass, on TMS, alt. 880-915 m, 772 8-2-5pp, 772 8-2-7, 772 8-2-11, 772 8-2-14, 772 8-2-20, 772 8-2-21, 772 8-2-24, 772 8-2-27; 3219CB, 51 km SSE of Algeria, Grootrivierhoogte, on quartzite (of the Table Mountain group), alt. 850-915 m, 768 11-2-1, 768 11-2-6pp; 3220DC, 60 km SW of Sutherland, on dolerite, alt. 820-850 m, 772 4-3-2, 772 4-3-4, 772 4-3-6; 3220DC, 34 km N of Matjiesfontein, Turck's Pass, on Ecca shale, alt. 1200-1235 m, 772 4-4-16; 3221BA, 37 km SSE of Fraserburg, Teekloof, on Beaufort mudstone, alt. 1160-1220 m, 772 10-5-4, 772 10-5-14; 3222BA, 13 km N of Beaufort West, Molteno Pass, on dolerite, alt. 1400-1460 m, 768 12-3-3pp; 3318CD, Table Mountain, Venus Transit Expedition of September 1874, A.E. Eaton (under *Parmelia hypoclysta* Nyl.) BM; 3319BC, 46 km ENE of Ceres, on Bokkeveld shale, alt. ± 900 m, 768 11-3-5pp, 768 11-3-7pp, 768 11-3-11, 768 11-3-12, 768 11-3-15; 3319CA, Erdumseglung S.M. Fregatte "Donau" 1868-71, Auf Felsen der höchsten Vrämme, Cap. d.g H., Bains Kloof, Dr. Wawra, W(1931) 12972pp; 3320AC, South Africa, Jan de Boers, on stone P.A. v.d. Bijl 1083, (under *Parmelia subcrustacea* Gyel.) W (1935)-; 3320BA, Kapland, Matjesfontein, grosse Karroo, sandstein, c. 900-950 m sm, J. Brunnthaler, 10/11/1909, W (1931) 8422; 3321AC, 38 km SE of Laingsburg, on Bokkeveld shale, alt. 610-760 m, 772 11-2-2, 772 11-2-3, 772 11-2-4, 772 11-2-7, 772 11-2-8, 772 11-2-9, 772 11-2-10, 772 11-2-11, 772 11-2-12, 772 11-2-13, 772 11-2-15, 772 11-2-16; 3321AD, Seven Weeks Poort near Ladismith, on TMS, alt. 915-945 m, 772 11-3-1pp, 772 11-3-5, 772 11-3-15pp, 772 11-3-29; 3322AC, 18 km S of Prince Albert, Top of Swartberg Pass, alt. 1700 m, 772 11-1-5 (TMS), 772 11-1-9 (Granite), 772 11-1-14 (on TMS), 772 11-1-19 (on TMS); 3322BB, 58 km WNW of Willowmore, on Ecca shale, alt. 760-915 m, 772 14-2-5, 772 14-2-6, 772 14-2-7, 772 14-2-8; 3322BC, 18 km N of De Rust, Meiringspoort, on Bokkeveld shale, alt. 640-730 m, 772 14-1-4, 772 14-1-9.

Xanthoparmelia colorata (Gyel.) Hale
Plate: 31C, 32C, and Dpp, Fig. 28. (p. 195).
Hale (1974) Phytologia, 28 (5): 486.

Parmelia colorata Gyelnik (1938) Sydowia Ann. Mycol., 36 (4): 272.
Holotypus: Bitterfontein, Namaqualand, P.A. v.d. Bijl, no 1192. W!

Thallus foliose; tightly adnate; on rock; up to 12 cm across. Lobes elongate to very elongate; uniformly appressed to the substrate; contiguous; 1½ to 8 mm, but prominently 3-6 mm broad; up to 4 cm long to the first complete transverse fissure; 150-400 µm thick. Obverse surface yellow-green; minutely felty to coarse pruinose; with a rudimentary epicortex; neither isidiate nor sorediate. Dorsal cortex 15-30 µm. Algal layer 20-80 µm. Medulla 80-250 µm. Ventral cortex 10-20 µm. Reverse surface pale brown to commonly black; sparsely to moderately rhizinate, with rhizines small to coarse.

Apothecia very frequent; when present sparse to abundant; substipitate; up to 1.5 cm across; often suburceolate but sometimes shallowly cupped. Hymenial surface black (livid brown when immature) sometimes fine white pruinose as well. Hymenium 50-70 µm. Subhymenium 10-20 µm. Exciple 30-70 µm. Ascospores, 8 per ascus; 7½-12 µm by 4½-7 µm (45/2).

Pycnia 100-200 µm in mean diameter. Pycnoconidia 6-8½ µm long.

Medulla faint pink but sometimes dirty orange towards the lower cortex; K+ yellow becoming blood-red; C- (but faint pink colour changing to faint yellow); P+ yellow-orange to orange. Pigmented (lower) portions of the medulla, K+ violet.

Chemistry:- Usnic acid in the upper cortex. Salazinic and norstictic acids, and sometimes two unidentified pigments, sch-1 and sch-2, in the medulla.

X. colorata is closely related to *X. schenckiana*, but differs from the latter in containing salazinic acid rather than protocetraric acid, and in being restricted to western and southern areas of the Karoo, rather than being widespread (fig. 28).

Specimens examined (Specimens marked with an asterisk (*) are pale below): 2917BD, 29 km N of Springbok, Vrieskloofhoogte/Ratelpoort, on white granite, alt. 880-940 m, 772 2-4-5, 772 2-4-6, 772 2-4-9; 2919AC, 40 km SW of Pofadder, Achab se berge (Part of Namiesberge) on quartzo-felspathic rock, alt. 960-1040 m, 772 3-2-2, 772 3-2-7; 3017BD, 19 km S of Kamieskroon, Karkams/Garagams, on granitic rock, alt. 760-790 m, 772 9-2-1, 772 9-2-10; 3018CA, 20 km SSE of Garies, on streaky augen gneiss, alt. 360-380 m, 772 9-1-1; 3019CD, 6 km S of Louriesfontein, Kubiskouberge, on dolerite, alt. 880-900 m, 772 3-4-3pp; 3119AC, 42 km NE of Vanrhynsdorp, halway up Vanrhyns Pass, on TMS, alt. 410-610 m, 768 10-1-10pp, *768 10-1-11; 45 km NE of Vanrhynsdrop, top of Vanrhyns Pass, on TMS,* alt. 800 m, 772 9-3-1, 772 9-3-2; <u>3120CD</u>, 12 km ESE of Middelpos on siltstone (Beaufort?), alt. 1250-1280 m, 772 4-2-14pp*, 772 4-2-15*, 772 4-2-17*; <u>3218BD</u>, 26 km S of Clanwilliam, Olifants river valley, on TMS, alt. 400-600 m, 772 8-1-19; <u>3219CB</u>, 51 km SSE of Algeria, Grootrivierhoogte, on orthoquartzite (of the TM group?), alt. 850-915 m, 768 11-2-6; <u>3221BA</u>, 16 km SSE of Fraserburg, Zaai Klipheuvels, on dolerite, alt. 1400-1430 m, 772 10-4-4*; <u>3321AC</u>, 38 km SE of Laingsburg, on Bokkeveld shale, alt. 610-760 m, 772 11-2-1, 772 11-2-5, 772 11-2-6, 772 11-2-14.

<u>*Xanthoparmelia columnata*</u> Hale ad int.

Plate 36C; Fig. 21. (p. 166).

Parmelia columnata Hale apud
Culberson and Hale (1973) Bryologist, <u>76</u>: 80.
(Almborn number-locality list in Almborn (1966)).

Thallus foliose; moderately to tightly adnate; up to 6 cm across. Lobes convex; very elongate to sublinear; uniformly appressed; discrete to contiguous; *0.8-1.5 mm broad; 300-650 µm thick. Upper surface* yellow-green; dull; with the epicortex pored to highly pored; strongly but sometimes indistinctly white maculate; non-isidiate and esorediate. Upper cortex 20-100 µm. Algal layer 40-80 µm. Medulla 50-500 µm. Lower cortex 30-60 µm, the lower portion dark brown in colour. Under surface black; mainly coarse rhizinate.

Apothecia fairly frequent; when present sparse to moderately abundant; substipitate; up to 5 mm across; shallowly cupped. Hymenium 40-60 µm. Subhymenium 5-10 µm. Exciple 30-60 µm. Ascospores, 8 per ascus, 8-13 µm by 4-6 µm (31/1). Pycnia 100-200 µm in average diameter. Pycnoconidia 5-8 µm long.

Medulla white or faint pink; K- at first, then + faint wine to mauve colour; KC- or a slight enhancement of the K reaction; C+ pale yellow fading, sometimes quite rapidly; P-.
Chemistry:- Usnic acid in the upper cortex, and hypoprotocetraric acid in the medulla, sometimes with 4-0-methylhypoprotocetraric acid.

This species occurs on the north-western margin, and is absent from the [illegible] western and southern margins where the allied *X. hypoprotocetrarica* is found (fig. 21). It resembles evenly appressed, convex lobed examples of *X. exornata*, but the black underside and the chemistry are more reminiscent of *X. hypoprotocetrarica*.
<u>Specimens examined</u>: <u>2917BD</u>, 29 km N of Springbok, Vrieskloofhoogte/Ratelpoort, on white gneiss, alt. 880-940 m, 772 2-4-10, 772 2-4-12, 772 2-4-22; <u>3017BD</u>, 19 km S of Kamieskroon, Karkams/Garagams, on gneiss, alt. 760-790 m, 772 9-2-9; <u>3219AA</u>, 20 km ENE of Clanwilliam, top of Pakhuis Pass, on TMS, alt. 900 m, 772 8-2-23, 772 8-2-25, 772 8-2-29; <u>3219AA</u>, 34 km NE of Clanwilliam, Klipfonteinrant, on TMS, alt. 300-450 m, 76[illegible] 10-3-7.

<u>Xanthoparmelia conspersa</u> (Ach.) Hale
Plate 23C; Fig. 27. (p. 191).
Hale (1974) Phytologia, <u>28</u> (5): 485.

Lichen conspersus Acharius (1798) Prod. Lich. Suec., p. 118.
For typification and synonomy see Hale (1964)
Bryologist, <u>67</u>: 466-468

Thallus foliose; tightly adnate; on rock. Lobes elongate; evenly appressed; contiguous; 80-200 µm thick; 0.3-1.0 mm wide. Upper surface green; dull to glossy; with small isidia, 0.03 to 0.1 mm thick by up to 0.2 mm high, simple or sometimes branched. [illegible]r surface black; sparsely small rhizinate.

Apothecia not seen. Pycnia not seen.

Medulla white; K+ yellow drying yellow-orange; C-; P+ yellow-orange.

Chemistry:- Usnic acid in the upper cortex; stictic, norstictic, constictic acids and St-1 in the medulla.

The above description refers to a single specimen only, and this species is known to be far more variable (Hale, 1964). It is probably more common in the eastern half of the country. The species is apparently widespread, and is common in Europe and eastern North America (Hale, 1964), but is rare in the Sonoran Desert in the western USA (Nash, 1974a).

Specimen examined: 3322AC, 18 km S of Prince Albert, top of Swartberg Pass, on coarse granite, alt. 1700 m, 772 11-1-9pp.

Xanthoparmelia constrictans (Nyl.) Hale

Plate 22A and B; 34D; Fig. 17. (p. 144).

Hale (1974) Phytologia, 28 (5): 486-487.

Parmelia constrictans Nylander apud Crombie (1876) Journ. Bot. Brit. & For., 14: 19.

Holotypus: Cape of Good Hope, Table Mountain, A.E. Eaton, "Venus Transit Expedition", Sept. 1874 (H-NYL! Isotypi, BM!).

Parmelia constrictans var *eradicata* Nylander apud Crombie (1876) Journ. Bot. Brit. & For., 14: 19.

Holotypus: Cape of Good Hope, Table Mountain, A.E. Eaton, "Venus Transit Expedition", Sept. 1874 (H-NYL! Isotypi BM!).

Parmelia conspersula Nylander apud Crombie (1876) Journ. Bot. Brit. & For., 14: 19.

Holotypus: Cape of Good Hope, Table Mountain, A.E. Eaton, "Venus Transit Expedition", Sept. 1874. (H-NYL! Other half of holotype and isotypes in BM!).

Parmelia conspersa var *constrictans* (Nyl.) Müller - Argoviensis (1883) Flora, 66: 48.

Parmelia conspersa var *eradicata* (Nyl.) Müller - Argoviensis (1883) Flora, 66: 48.

Imbricaria constrictans (Nyl.) Jatta (1902) Nouvo G. Bot. Ital. (Nuova ser.), 9: 470.

Imbricaria constrictans var *eradicata* (Nyl.) Jatta (1902) Nuovo G. Bot. Ital. (Nuova ser.), 9: 470.

Parmelia eradicata (Nyl.) Gyelnik (1938) Ann. Mus. Natn. Hungarici (Pars Bot.), 31: 25.

Xanthoparmelia conspersula (Nyl.) Hale (1974) Phytologia, 28 (5): 486.

Xanthoparmelia eradicata (Nyl.) Hale (1974) Phytologia, 28 (5): 487.

Thallus extremely variable; crustose, foliose to subfruticose; crustose to loosely adnate; on rock, on soil adjacent to rock, over and intermingled with mosses and other lichens; up to 12 cm in diameter. Lobes elongate to linear; evenly appressed to subascending to not all appressed; discrete to highly imbricate; 0.1-2.0 mm broad; 70-220 µm thick. Upper surface green, becoming olive green, to sometimes brown in the interior; glossy, but sometimes dull; with a pored epicortex; isidia, soredia and maculae absent. Upper cortex 10-20 µm. Algal layer 20-50 µm. Medulla 40-130 µm. Lower cortex 5-15 µm. Under surface black, becoming chestnut brown to tan at some lobe tips; with rhizines absent to moderately abundant and small to coarse in size.

Holotypus: Cape of Good Hope, Table Mountain, A.E. Eaton, "Venus Transit Expedition", Sept. 1874. (H-NYL! Other half of holotype and isotypes in BM!).

Parmelia conspersa var *constrictans* (Nyl.) Müller - Argoviensis (1883) Flora, 66: 48.

Parmelia conspersa var *eradicata* (Nyl.) Müller - Argoviensis (1883) Flora, 66: 48.

Imbricaria constrictans (Nyl.) Jatta (1902) Nouvo G. Bot. Ital. (Nuova ser.), 9: 470.

Imbricaria constrictans var eradicata (Nyl.) Jatta (1902) Nuovo G. Bot. Ital. (Nuova ser.), 9: 470.

Parmelia eradicata (Nyl.) Gyelnik (1938) Ann. Mus. Natn. Hungarici (Pars Bot.), 31: 25.

Xanthoparmelia conspersula (Nyl.) Hale (1974) Phytologia, 28 (5): 486.

Xanthoparmelia eradicata (Nyl.) Hale (1974) Phytologia, 28 (5): 487.

Thallus extremely variable; crustose, foliose to subfruticose; crustose to loosely adnate; on rock, on soil adjacent to rock, over and intermingled with mosses and other lichens; up to 12 cm in diameter. Lobes elongate to linear; evenly appressed to subascending to not all appressed; discrete to highly imbricate; 0.1-2.0 mm broad; 70-220 μm thick. Upper surface green, becoming olive green, to sometimes brown in the interior; glossy, but sometimes dull; with a pored epicortex; isidia, soredia and maculae absent. Upper cortex 10-20 μm. Algal layer 20-50 μm. Medulla 40-130 μm. Lower cortex 5-15 μm. Under surface black, becoming chestnut brown to tan at some lobe tips; with rhizines absent to moderately abundant and small to coarse in size.

Apothecia rare on "eradicatoid" morphs, otherwise common; when present sparse to moderately abundant; adnate to substipitate; up to 8 mm across; convex to shallowly cupped. Hymenium 50-70 µm. Subhymenium 20-40 µm. Exciple 30-100 µm. Ascospores 7½-11 µm by 4½ to 6½ µm. Pycnia 100-200 µm in mean diameter. Pycnoconidia 5-8 µm long.

Medulla white to pale rose; K+ either yellow, or yellow becoming blood-red; C-; P+ yellow-orange to orange.

Chemistry:- Usnic acid in the upper cortex. Salazinic acid sometimes with norstictic acid, or stictic, constictic (4-O-methylsalazinic) acids sometimes with norstictic, hypostictic acids and St-1, in the medulla.

The present treatment of this species is only a tentative one, as it is based on relatively few specimens, mainly on those collected from the top of Swartberg Pass where a large amount of variation was found.

Three names have been associated with this very variable species: *X. constrictans*, *X. eradicata*, and *X. conspersula*, referring to the broad and narrow lobed loosely adnate forms, and the crustose state respectively. The holotype of *X. conspersula* is crustose but some marginal lobes are narrow and linear, surely the beginnings of the "eradicatoid" condition of this species. Another specimen, 772 11-1-4pp, shows broader lobes developing from a subcrustose thallus margin (plate 34D) the beginnings of the type habit. Other specimens of this species are clearly foliose but the lobes are tightly adnate and uniformly appressed (772 11-1-2, 772 11-1-6, 772 11-1-8pp, 772 11-1-17), while others start a subascending mode of growth quite early (772 11-1-8pp). It is assumed that as the lobes proliferate from the latter condition, the thallus becomes loosely adnate. Although the loosely adnate specimens are often either of the type habit or "eradicatoid", the two states are not mutually exclusive as: (a) the lobe type of the opposite habit can be found in many thalli; (b) the habit may change around a corner (i.e. with change in microaspect) e.g. 772 11-1-20; (c) some thalli are difficult to place in any of the named habit types because the lobes are predominantly of intermediate width (e.g. 772 6-1-2).

The type and "eradicatoid" habits have been found on the same microaspect of a rock, a characteristic that has been used to support the separation of taxa at the varietal level (Moberg, 1977). This is re-enforced by the fact that in the few examples seen (772 11-1-1, 772 11-1-16), the opposite habit states had differing chemistries. The above evidence could be used to support the recognition of 1, 2, 3 or 6 separate taxa, but this is regarded to be beyond the scope of the present collections.

X. tasmanica may be similar to broader lobed specimens of *X. constrictans*, but the former species is often broader lobed, and the narrower lobes lack the conspicuous constrictions of the latter species. The lobes of the former species are discrete, contiguous or imbricate in a few layers that are closely appressed to one another, whereas those of the latter species are often imbricate in many layers and not at all appressed to one another, (Thallus open and loose in structure).

X. tasmanica is also distinct from *X. constrictans* in that it contains salazinic acid only. The broad lobed *X. hypopsila* (Müll. Arg.) Hale containing stictic acid and associates in the medulla, is rare, and is different to *X. tasmanica* in the foliose nuances displayed. Another species of doubtful affinity to *X. constrictans* is *X. suberadicata* (des Abbayes) Hale. Although the type material has not been seen, a diagram in the original publication of this species (des Abbayes, 1961), shows the general lack of constrictions. The name is thought to be more correctly applied to specimens such as those found at Oribi gorge in Natal.

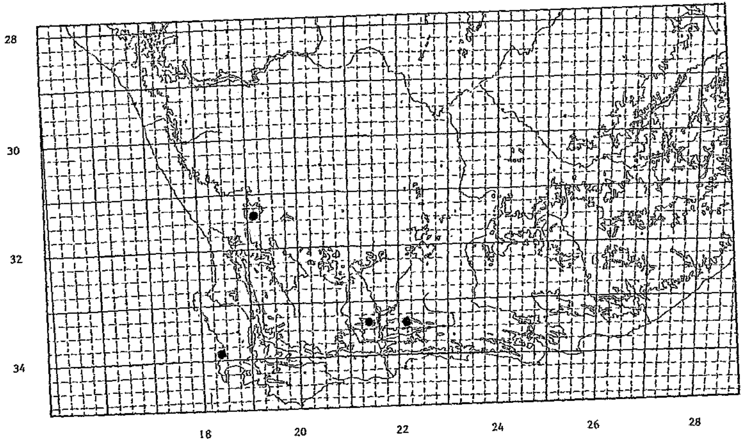


Fig. 17 Distribution of *Xanthoparmelia constrictans*

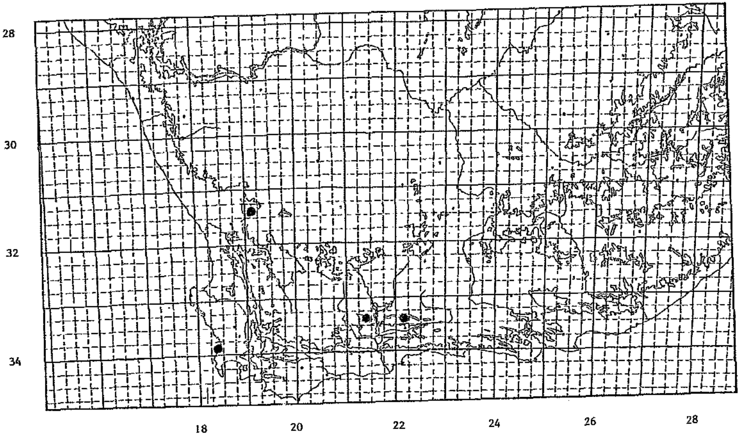


Fig. 17 Distribution of *Xanthoparmelia constrictans*

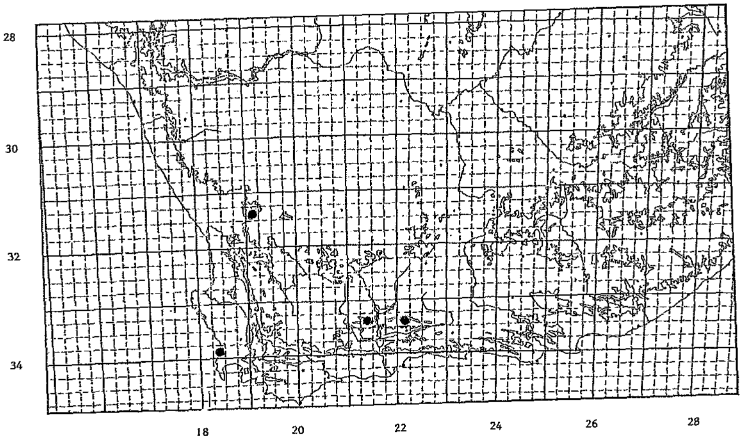


Fig. 17 Distribution of *Xanthoparmelia constrictans*

(7812 27-1. 7812 27-2), with thicker lobes and subascending habit, somewhat reminiscent of *X. hypoprotocetrarica* p.p. in morphology, but without the maculation on the upper surface. *X. suberadicata* contains the stictic acid ensemble in the medulla.

Specimens examined: (The following abbreviations are used to denote the form and chemical strain of the specimens: (i) - salazinic acid present in the medulla; (ii) - the stictic acid ensemble present in the medulla; c - predominantly broad lobed (0.5-2.0 mm broad), conspicuously constricted, loosely to tightly adnate; e - predominantly narrow lobed (0.1-0.3 mm wide), loosely adnate or composed of subascending lobes; sc - thallus subcrustose developing the c-type lobes, se - crustose developing e-type lobes.): 3119AC, 45 km NE of Vanrhynsdorp, top of Vanrhyns Pass, on TMS, alt. 800 m, 768 10-2-6 (ii) c/sc; 3318CD, Table Mountain, A.E. Eaton, "Venus Transit Expedition" of September 1874, (i) c, (i)e, (i)sc in BM & H-NYL; 3321AD, Seven Weeks Poort near Ladismith, on TMS, alt. 915-945 m, 772 11-3-18pp. (i)c, 772 11-3-27 (i)e, 772 11-3-44 (ii)c; 3322AC, 18 km S of Prince Albert, top of Swartberg Pass, on TMS, alt. 1700 m, 772 11-1-1 (i)c & (ii) e, 772 11-1-2 (ii) c, 772 11-1-3 (i)c & (ii) e, 772 11-1-4 (ii)c & (ii) sc, 772 11-1-6 (ii)c, 772 11-1-12 (ii)c, 772 11-1-16 (i) c & (ii)e, 772 11-1-17 (ii)c & (ii)e & (i) [illegible], 772 11-1-18 (ii)c, 772 11-1-20 (ii)c & (ii)e, 772 11-1-21 (i)c, 772 11-1-22 (ii)c, 772 11-1-23 (i)c, 772 11-1-24 (i)c, 772 11-1-25 (i)c, 772 11-1-26 (ii)c.

Xanthoparmelia dichromatica (Hale) Hale

Plate 27A, and B, Fig. 18. (p. 147).

Hale (1974) Phytologia, 28 (5): 487.

Parmelia dichromatica Hale (1971) *Bot. Not.*, 124: 348,

Fig. 1 D.

Holotypus: Africa australis, prov. O.F.S., distr.
Thabanchu, On Mt Thabanchu, 5500-7000! Leg. O.A. Höeg,
12/8/1929. TRH!

Thallus foliose; moderately to tightly adnate; on rock; 3-8 cm across. Lobes elongate; evenly appressed; contiguous; 1-5 mm, but usually 2-4 mm broad; 100-300 μm thick; often fragile. Upper surface green; glossy to dull; with a pored epicortex; not maculate; non-isidiate and esorediate; often highly wrinkled and bullate in the interior. Upper cortex 20-30 μm. Algal layer 20-30 μm. Medulla 60-200 μm. Lower cortex 5-15 μm. Lower surface pale brown; moderately rhizinate.

Apothecia frequent; when present sparse to abundant; substipitate; up to 11 mm across; shallowly cupped. Hymenium 40-60 μm. Subhymenium ± 10 μm. Exciple 15-50 μm. Ascospores, 8 per ascus, 6-10 μm by 4½-6½ μm (66/2). Pycnia 100-200 μm in mean diameter. Pycnoconidia 5-8 μm long.

Medulla white with deep maroon to purple spots; K−; KC+ pale wine rose; C−; P+ orange to orange-red. Pigment spots, K+ deep purple. Chemistry:- Usnic acid, protocetraric acid and one to all of the unknown pigments found in *X. endomiltodes* (Endo-1 to Endo-4), but commonly with Endo-3 and Endo-4 in major amounts.

X. dichromatica is always normally foliose and is conservative in its morphological variation. It is common in the eastern part of the central Karoo, but is rarer to the south of this area. It appears to be common in the Drakensberg and surrounding areas (Fig. 18).

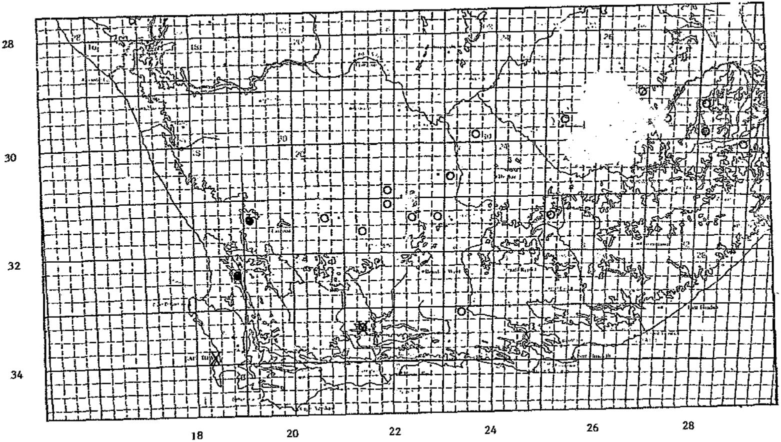


Fig. 18 Distribution of *Xanthoparmelia dichromatica* (O), *X. endomiltodes* (X) and ... *ianthina* (●).

This species is not easily mistaken for any other, and resembles *X. subdecipiens* morphologically. The two species differ markedly in their chemistries, *X. subdecipiens* containing aliphatic acids and *X. dichromatica* containing protocetraric acid and the *X. endomiltodes* pigments. Possibly more closely related are *X. endomiltodes* and *X. ianthina* with the same pigments, but these are usually distributed thoughout the medulla in these two species, and the depside/depsidone chemistries differ also. An undescribed *Neofuscelia* is also similar to *X. dichromatica* in containing protocetraric acid and the pigments Endo-1 to Endo-4, but again these pigments are distributed throughout the medulla while the upper cortex lacks usnic acid and is brown coloured. All these species containing endo-1 to endo-4 are consistently pale brown below.

Specimen list (bracketed specimens not seen, but taken from Hale, 1971): (2828DC, Oxbow valley, distr. Leribe (Lesotho) L. Kofler 3-11-7022a, LD); 2923DC, Strydenburg, on dolerite, alt. 1080-1110 m, 768 5-2-5, 768 5-2-8; (2925CB, Fauresmith, O.F.S., Henrici, 1939, PRE); 2926BB/BD, Mt. Thaba 'Nchu, distr. Thaba 'Nchu on Clarens (Cave) sandstone, alt. 1680-2130 m, O.A. Höeg 12/8/1929, TRH; (2927CB, Masite Mt., distr. Maseru (Lesotho), Hewitt, 1929-30, TRH); (2928AC, Blue Mountain Pass, Maluti Range, distr. Marakabei, L. Kofler, 2/6/63, alt. 2900 m, LD, US); 2928CG, Maletsunyane Falls, Semongkong, distr. Marakabei, on basalt, 7611 30-4pp; (2929AC, Mokhotlong, distr. Mokhotlong, L. Kofler, 7/2/1963, LD); 3021DD, 15 km W of Carnarvon, on Ecca siltstone, alt. 1220-1370 m, 768 7-1-1pp.; 3023CA, 32 km W of Britstown, on dolerite, alt. 1140-1160 m, 768 6-2-1, 768 6-2-2; (3028BB, 10 km from Ramat-seliso, distr. Qachas Nek, L. Kofler, 13/11/63, LD); 3120BC, 34 km W of Williston, Jan Swartsberg, on dolerite, alt. 1170-1200 m, 772 10-2-11; 3121BB, 40 km WSW of Carnarvon, Klipheuvels, on dolerite, alt. 1310-1330 m, 768 7-2-4; 3121CB, 27 km NW of Fraserburg, Blydevooruitzicht, on Beaufort mudstone, alt. 1250-1265 m, 772 10-3-1, 772 10-3-4; 3122AD, 3 km NNW of Loxton on Beaufort siltstone, alt. 1370-1525 m, 772 15-4-1, 772 15-4-12, 772 15-4-14, 772 15-4-20, 772 15-4-22; 3122BD, 27 km W of Victoria West, Gap Kop, on dolerite, alt. 1370 m, 772 15-3-3, 772 15-3-7, 772 15-3-9, 772 15-3-11, 772 15-3-13, 772 15-3-14, 772 15-3-15, 772 15-3-17, 772 15-3-18, 772 15-3-19, 772 15-3-21; (3125AC, Rosemead, distr. Middleburg, O.A. Höeg, 3/12/1929, TRH); 3221BA, 37 km SSE of Fraserburg, well down Teekloof, on Beaufort mudstone, alt. 1160-1220 m, 772 10-5-10, 772 10-5-11; 3321AD, Seven Weeks Poort near Ladismith, on TMS, alt. 915-945 m, 772 11-3-2; 3323AB, 14 km N of Willowmore, Perdepoort, on Witteberg rock, alt. 850-880 m, 772 14-3-7.

Xanthoparmelia dysprosa sp. nov.

Plate 17C, & D; Fig. 20. (p. 161).

Thallus ut in *X. hypoleia* (Nyl.) Hale, sed vice acidi protocetrarici, acidum evernicum continente differt.

Holotypus: South Africa, Cape Province, 3218BD, 25 km S of Clanwilliam, Olifants river valley, on TMS, alt. 400-600 m, 772 8-1-6.

Thallus as in *X. hypoleia* (Nyl.) Hale, but differs in containing evernic acid instead of protocetraric acid.

Medulla: white; K-; C-; KC+ pale orange; P-.

Chemistry:- Usnic and evernic acids.

This species is known only from the holotype specimen. It is difficult to discriminate between *X. burmeisteri*, *X. dysprosa*, and *X. hypoprotocetrarica* on the grounds of morphology and spot tests alone, and TLC must be used to positively identify these species.

Xanthoparmelia endomiltodes (Nyl.) Hale

Fig. 18. (p. 147).

Hale (1974) Phytologia, 28 (5): 487.

Parmelia endomiltodes Nylander apud Crombie (1876) J. Linn. Soc.
Lond. Bot., 15: 168.
Holotypus: Cape of Good Hope, Table Mountain, "Venus
Transit Expedition", Sept. 1874.
A.E. Eaton H-NYL 34793! (Isotypi : BM!).
Parmelia conspersa var *endomiltodes* (Nyl.) Müller - Argoviensis
(1891) Flora, 71: 378-379.

Thallus foliose; moderately to tightly adnate; on rock; up to 6 cm across. Lobes elongate; evenly appressed; contiguous; 0.5-2.0 mm broad; 80-200 µm thick; fragile. Upper surface green to olive green; glossy to dull in the interior; pored epicorticate; esorediate and non-isidiate; non-maculate or sometimes faintly so. Upper cortex 12-20 µm. Algal layer 20-50 µm. Medulla 20-140 µm. Lower cortex 5-15 µm, hyaline. Under surface pale fuscous to creme; sparsely to moderately rhizinate, rhizines small to moderate sized.

Apothecia infrequent; when present sparse; substipitate; up to 2.5 mm across; shallowly cupped. Hymenium 40-60 µm. Subhymenium ± 20 µm. Exciple 20-30 µm. Asci subcylindrical. Ascospores 8 per ascus, irregularly uni- to biseriate, 7-11 µm by 4-6½ µm.
Pycnia 100-150 µm in mean diameter. Pycnoconidia 5-7 µm long.

Medulla maroon to mauve, but often becoming white towards the lower cortex; K+ deep purple; reactions of salazinic acid obscured by the pigments.

Chemistry:- Usnic acid, salazinic acid and 4 anthroquinoid pigments, endo-1 to endo-4, with the possibility of a fifth one occurring as well.

This species has been collected form Seven Weeks Poort only, all other similar specimens being the new species *X. ianthina*. To date the specimens indicate that *X. endomiltodes* has a southerly distribution, and *X. ianthina*, containing unknown β-orcinol *meta*-depsides, a westerly distribution. *X. dichromatica* differs from the above two species in containing *protocetraric* acid, with the pigments restricted to small finite volumes of medulla, often near pycnia. An undescribed *Neofuscelia* species also contains these pigments in the medulla, but in this case protocetraric acid is again *present without usnic* acid in the upper cortex. *Pseudoparmelia violacea* (Kurok.) Hale also contains these pigments but the upper cortex lacks both usnic acid and the brown colouration of the Neofusceliae. Atranorin is *also* reported *absent* (Hale and Kurokawa, 1964; Hale, 1976a).

Specimens examined: 3218CD, Table mountain, on TMS, A.E. Eaton, Sept. 1874, H-NYL 34793, BM; 3321AD, Seven Weeks Poort near Ladismith, on TMS, alt. 915-945 m, 772 11-3-3-pp, 772 11-3-16.

Xanthoparmelia exornata (Zahlbr.) nov. comb.

Plate 15D; 18; 36D. Fig. 19. (p. 154).

Parmelia conturbata var *exornata* Zahlbrückner (1932) Ann. Crypt. Exot., 5: 251-252.
Holotypus: Namaqualand, Steinkopf. Leg. Pastor G. Meyer, P.A. v.d. Bijl no. 950 (W (1934) 315!).

Thallus foliose; loosely to tightly adnate; on rock; up to 10 cm across. Lobes plane to convex; elongate to sublinear; commonly evenly appressed, but sometimes not at all appressed; discrete to highly imbricate; mostly 1-4 mm broad; 150-800 µm thick; tough and leathery to brittle. Upper surface green, becoming darker or brown in the interior; heavily pale maculate (plate 18D), maculae irregular to rosetted, discrete to largely confluent; epicortex pored, often in finite areas (plate 4); not isidiate or sorediate. Upper cortex uneven to extremely uneven, 10-250 µm thick, the upper 10-30 µm obscured by usnic acid. Algal layer uneven to very uneven, unbroken to broken, basically 20-100 µm thick, but rising to, and falling away from the upper surface at intervals, to give apparent vertical thicknesses of up to 400 µm. Medulla 100-600 µm. Ventral cortex 20-40 µm, pale brown to very dark brown in section. Lower surface frequently tan, but rarely black; usually moderately rhizinate, rhizines moderate to coarse in size.

Apothecia: common; when present sparse to moderately abundant; substipitate; up to 7 mm across; shallowly cupped. Hymenium 40-60 µm. Subhymenium 5-15 µm. Exciple 30-120 µm, but commonly 30-60 µm. Ascospores 8 per ascus, 7-11 µm by 5-6½ µm (97/4).

Pycnia 100-200 µm in mean diameter. Pycnoconidia 5-8 µm long.

Chemistry:- This species can be considered to be composed of an intergrading series of 4 chemical variants, all with usnic acid, rarely together with atranorin, in the upper cortex. (i) Medulla white, with no lichen substances present; K-; P-. (ii) Medulla faint pink, with salazinic acid, and with little or none of the "chalybaeizans unknown" present; K+ yellow becoming blood-red; P+ orange. (iii) Medulla pale yellow to pale dirty yellow, with the "chalybaeizans unknown" and little or no salazinic acid present; K+ yellow-orange, darkening on drying; P+ orange. (iv) Medulla pale yellow to dirty yellow, with approximately equal amounts of salazinic acid and the "chalybaeizans unknown"; K+ rich yellow to yellow-orange, becoming blood-red; P+ orange. The relationship of

(i) to the rest, is one of total concentration of lichen substances, whereas that of (ii) to (iii) is one of relative concentration with (iv) as a central point between (ii) and (iii).

This species is widespread in the Karoo, but is commoner on the moister marginal areas. It shows a large amount of foliose variation, commonly being represented by thalli that are evenly appressed and convex-sublinear lobed throughout (plate 18A), but becoming normally (plane) foliose or highly imbricate in moister localities (plate 18B, and C).

X. leucostigma appears to be similar to *X. exornata*, but its habit range is not known and it differs in containing gyrophoric acid. All other maculate species have black undersurfaces. Some (type (iii) and (iv)) chemical variants of this species may resemble *X. chalybaeizans*, because the maculae are largely confluent. However careful examination of the tips and edges of the lobes may reveal maculae. *X. exornata* has thicker lobes and a different habit range.

Specimens examined: 2917BC, Namaqualand, Steinkopf, Leg. Pastor G. Meyer (P.A. v.d. Bijl no. 950) W (1934) 315; 2917BD, 29 km N of Springbok, *Vrieskloofhoogte/Ratelpoort, on white gneiss, alt. 880-940 m,* 772 2-4-20, 772 2-4-21; 2919BC, 32 km SSE of Pofadder, on quartz, alt. 1040-1050 m, 768 9-4-3, 768 9-4-6; 2928CC, (Lesotho) Maletsunyane Falls near Semongkong, on basalt, 7611 30-4, 3018CA, 20 km SSE of Garies, on gneiss, alt. 360-380 m, 772 9-1-4, 772 9-1-21, 772 9-1-28, 772 9-1-29, 772 9-1-31, 771 9-1-36; 3019CD, 6 km S of Louriesfontein, Kubiskouberg, on dolerite, alt. 880-900 m, 772 3-4-10, 772 3-4-25, 772 3-4-27, 772 3-4-28; 3023BA, 22 km S of Strydenburg, on dolerite, alt. 1200 m, 768 5-3-2; 3119AC, 45 km NE of Vanrhynsdorp, top of Vanrhyns Pass, on TMS, alt. 800 m, 768 10-2-18, 772 9-3-5, 772 9-3-9; 3120CA, 48 km NW of Middelpos, on dolerite, alt. ± 1200-1300 m, 772 4-1-5B; 3120CD, 12 km ESE of Middelpos, on Beaufort siltstone, alt. 1400 m, 772 4-2-17pp; 3123CC, Three Sisters, on

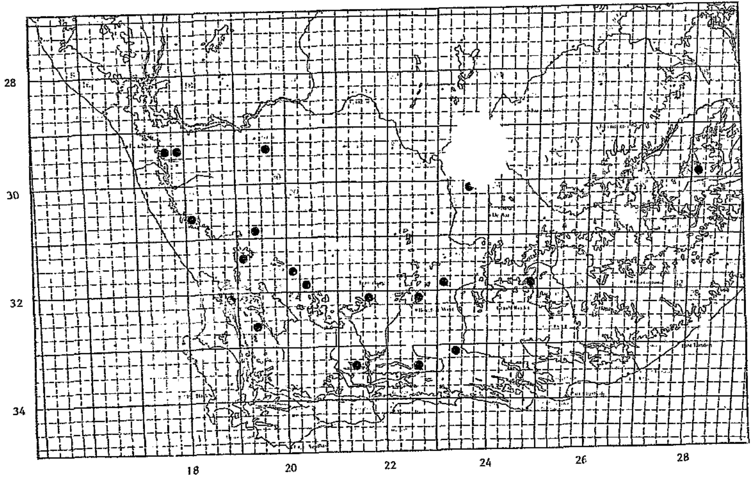


Fig. 19 Distribution of *Xanthoparmelia exornata.*

dolerite, alt. 1110-1200 m, 768 12-4-4; 3124DD, Lootsberg Pass, between Graaff-Reinet and Middleburg, on Beaufort mudstone, alt. 1800 m, 772 15-2-13, 772 15-2-15, 772 15-2-16; 3218BB, 11 km NE of Clanwilliam, Pakhuis Pass, Pakhuisberge, on TMS, alt. 700 m, 772 8-3-4, 772 8-3-7, 772 8-3-11; 3219CB, 50 km SSE of *Algeria*, *Grootrivierhoogte*, on TMS, alt. 1000 m, 768 11-2-1, 768 11-2-2, 768 11-2-11; 3221BA, 16 km SSE of Fraserburg, Zaai Klipheuvels, on dolerite, alt. 1400 m, 772 10-4-2, 772 10-4-7, 772 10-4-9, 772 10-4-10; 3222BA, 13 km N of Beaufort West, Molteno Pass, on dolerite, alt. 1400-1450 m, 768 12-3-1 (Usnic acid only); 3321AD, Seven Weeks Poort near Ladismith, on TMS (or soil on rock?), alt. 950 m, 772 11-3-10, 772 11-3-19, 772 11-3-21, 772 11-3-24, 772 11-3-26, (772 11-3-44, 772 11-3-45); 3322BC, 18 km N of De Rust, Meiringspoort, on Bokkeveld shale, alt. 640-730 m, 772 14-1-4, 772 14-1-8, 772 14-1-28; 3323AB, 14 km N of Willowmore, Perdepoort, on Witteberg rock, alt. 850-880m, 772 14-3-11 (Usnic acid only).

Xanthoparmelia globulifera (Kurok. et Filson) comb. nov.

Plate 23D; Fig. 30. (p. 207).

Basionomen: *Parmelia globulifera* Kurokawa et Filson (1975) Bull. Nat. Sci. Mus. Ser B. (Bot.) 1 (1): 38-39.

Holotypus: Growing on granite in exposed situation. *Wynbring Rocks*, 1.2 km north of Wynbring on Transcontinental Railway Line, South Australia, R. Filson 11940 p. maj. p. MEL (not seen).

Thallus foliose; moderately adnate; on rock and other foliose lichens. Lobes elongate; contiguous to imbricate; 0.3 to 3.0 mm broad; 100-250 µm thick. Upper surface green; glossy to dull in the interior; isidiate, isidia usually globose but sometimes cylindrical, 0.05-0.2 mm thick, by up to 0.3 mm long, the tips sometimes breaking off cleanly; esorediate; non-maculate. Upper cortex 10-20 µm. Algal layer 20-50 µm. Medulla 40-160 µm. Lower cortex 15-20 µm. Lower surface tan; moderately rhizinate.

Apothecia sparse when present; substipitate; up to 3 mm across; shallowly cupped. Hymenium 40-60 µm. Subhymenium 10-15 µm. Exciple 30-60 µm. Ascospores 8 per ascus, 7½-9½ by 5-6 µm (few measured). Pycnia 100-200 µm in mean diameter. Pycnoconidia not seen.

Medulla: white; K-; C-; KC-; P-.

Chemistry:- Usnic acid and two unidentified aliphatic acids.

The present species was first described from Australia (Kurokawa and Filson, 1975) and although there are morphological and habit differences between the Cape specimens and the type description, these are considered to be insignificant in comparison to the variation found in other similar Xanthoparmeliae. The chemistries of the Cape specimens and the type appear to differ; the latter containing caperatic acid which was not found in the former. However the aliphatic acids in the Cape specimens were not identified, and the chemical relationships remain unknown.

No true non-isidiate counterpart exists in the present collections, and although the overall similarity to X. subdecipiens is quite striking, its aliphatic acid chemistry is consistently different.

Specimens examined: 3218BD, 26 km S of Clanwilliam, Olifants river valley, on TMS, alt. 400-600 m, 772 8-1-5; 3321AD, Seven Weeks Poort near Ladismith, on TMS, alt. 915-945 m, 772 11-3-13, 772 11-3-31; 3322BC, 18 km N of De Rust, Meiringspoort, on Bokkeveld shale, alt. 640-730 m, 772 14-1-11, 772 14-1-20pp.

Xanthoparmelia heterodoxa (Hale) Hale

Plate 35B; Fig. 26. (p. 189).

Hale (1974) Phytologia, 28 (5): 487.

Parmelia heterodoxa Hale (1971) Bot. Not., 124: 349, fig. 2C.
Holotypus: On rocks, Natal Table Mountain, distr. Pietermaritzburg, South Africa, O. Almborn 8595, 30 October 1953 (LD, isotypus US).

Thallus crustose; on rock; up to 3.5 cm across; areolate in the centre but lobate at the margins. Lobes mostly elongate, *sometimes* very elongate; contiguous, 0.2-0.8 mm wide; up to 5 mm long to the first transverse fissure; always less *than 100 µm thick. Upper surface* green, dull to minutely felty; with the epicortex absent or rudimentary; neither isidiate nor *sorediate. Lower surface only present* at the lobe tips; pale brown to ivory; without rhizines.

Apothecia frequent; when present sparse to abundant; immersed in the areoles, but sometimes somewhat sessile, up to 0.4 mm in diameter; *plane. Hymenium surface* livid brown or black. Hymenium 60-80 µm. Subhymenium shallowly conical, 0-50 µm. Exciple funnelled, 15-20 µm. Asci *subcylindrical.* Ascospores 8 per ascus, 7½-9½ µm by 4½-6½ µm. Pycnia small, up to 50 µm in mean diameter. Pycnoconidia 7-11 µm long.

Medulla (very thin): white; K-; C-; KC-; P-.

Chemistry:- Usnic acid in the upper cortex. Evernic acid sometimes with lecanoric acid (?) in the algal layer and medulla.

Although the unseen holotype specimen differs from the present specimens in habit, they conform to the type morphologically. The habit difference is considered to be environmentally induced. All the examined specimens contain evernic acid and one contained lecanoric acid as well, but the latter specimen was too small to confirm either substance by microhydrolysis. (The type was tentatively reported to contain olivetoric acid). The placement of this species in *Xanthoparmelia* is somewhat dubious as the apothecial structure is at variance with what is typical for the genus. However, until the distinction between the Parmeliae (sensu lato) and the lobate Lecanorae is clarified, *X. heterodoxa* is probably better placed in *Xanthoparmelia.*

X. heterodoxa has been found as far south as Ladismith in the Cape, and as far north as the Natal Table Mountain.

This diminutive species cannot be confused with any other species except *X. ralla*, from which it differs in containing evernic acid rather than the norlobaridone of the latter species.

Specimen List: (2930DA, Natal Table Mountain, O. Almborn 8595, 30 October 1953, not seen); 3124DD, Lootsberg Pass, halfway between Graaff-Reinet and Middleburg, on Beaufort mudstone, alt. 1800 m, 772 15-2-5, 772 15-2-6 p.min.p., 772 15-2-25pp.; 332[illegible], Seven Weeks Poort near Ladismith, on TMS, alt. 915-945 m, 772 11-3-8 p.min.p.

Xanthoparmelia hypoleia (Nyl.) Hale

Plate 14; Fig. 20. (p. 161).

Hale (1974) Phytologia, 28 (5): 487

Parmelia hypoleia Nylander (1860) Synopsis
Methodica Lichenum, v.1, p. 393.
Holotypus: C.B.S., sub *Parmelia reticulata* Nees (FH!).

Parmelia hypoleia var *tenuifida* Nylander (1860)
Synopsis Methodica Lichenum, v.1, p.393.
Type material in hb. Carr., not located and not seen.

Parmelia hypoleia var *crenata* Nylander apud Hue (1890)
Nouv. Arch. Mus. Paris [Sér. 3], 2: 290.
Holotypus: Cap. B. Spei, Cueinzius (H-NYL 34824!).

Parmelia hypoleioides Vainio (1926) Ann. Univ. Fenn. Abo.
[Ser A], 2 (3): 1-2.
Holotypus: Africa austr., Paarl, on stones.
Miss van Velden, 1921, no. 334 (Hb. Vain. no. 34578)
(TUR-VAIN!)

Parmelia hypoleia f. *hypoleioides* (Vain.) Gyelnik (1938).
Ann. Mus. Natn. Hungarici, [Pars Bot], 31: [illegible]9.

Thallus foliose to subfruticose; loosely to moderately adnate; on rock or sometimes soil; up to 10 cm across. Lobes horizontal to subascending; elongate to linear; contiguous to highly imbricate; 0.3-5 mm broad; 100-600 µm thick. Upper surface green; glossy to dull; pored epicorticate, strongly to sometimes weakly pale maculate (*rarely* emaculate, e.g. 772 11-1-7); not isidiate or sorediate. Upper cortex uneven to even, 20-60 µm. Algal layer uneven to even and sometimes interrupted, [illegible]-60 [-80] µm thick. Medulla uneven, 100-400 µm. Lower cortex 2-3 cell layers thick, 10-50 µm. Lower surface black, sometimes becoming chestnut brown at the lobe tips; with rhizines absent to moderately abundant, rhizines up to 1½ mm long.

Apothecia common; when present, sparse to abundant; substipitate; up to 1.2 cm across; shallowly cupped. Hymenium 40-60 µm. Subhymenium 5-15 µm. Exciple 30-60 µm. Ascospores 8 per ascus, 8-12 µm by 4½-7 µm. Pycnia 100-200 µm in mean diameter. Pycnoconidia 5-8 µm long.

Medulla white; K-; KC+ pale rose; C-; P+ orange-red.
Chemistry:- Usnic, protocetraric and virensic acids consistently present. Skyrin sometimes present in the lower medulla.

X. hypoleia appears to be endemic to southern Africa, but *X. pseudohypoleia* (Elix) ad int., reported to contain the closely related fumarprotocetraric acid, is found in Australia (Elix, 1976). In the present collection, *X. hypoleia* was found as far north as Garies on the western margin, and as far east as the Swartberg Pass north of Oudtshoorn, on the southern margin, but the species is known from as far east as Uitenhage (type material of *P. mutabilis* Tayl.).

X. hypoleia is the most commonly collected species of the *X. hypoleia* group, and is distinguished from the other members of this group by the K- and P+ orange-red reaction of the medulla, caused by the presence of protocetraric and virensic acids. The group as a whole stands apart form the other Karoo Xanthoparmeliae in the black lower surface and the maculate upper surface. The species of this group are all similar to each other, and are differentiated mainly on the basis of their chemistries. In this respect they may be regarded as chemical strains of *X. hypoleia* (sensu lato), but the individual chemistries, and habit ranges (although overlapping partly) may differ widely. The only species distinguished on the basis of thallus habit, is *X. columnata*, with its evenly appressed convex lobes, reminiscent of *X. exornata*. However, *X. columnata* is similar to *X. hypoprotocetrarica*, but no specimens with the *X. columnata* habit were found to contain protocetraric and virensic acids, common substances in the normal habit range of the *X. hypoleia* group. This group is also present in Australia and at least two species, *X. burmeisteri* and *X. hypoprotocetrarica*, are present in both the Cape and Australia.

Specimens examined: 3018CA, 20 km SSE of Garies on gneiss, alt. 360-380 m, 772 9-1-30, 772 9-1-32pp, 772 9-1-34pp; 3019CD, 6 km S of Louriesfortein, Kubiskouberg, on dolerite, alt. 880-900 m, 772 3-4-15pp, 772 3-4-19, 772

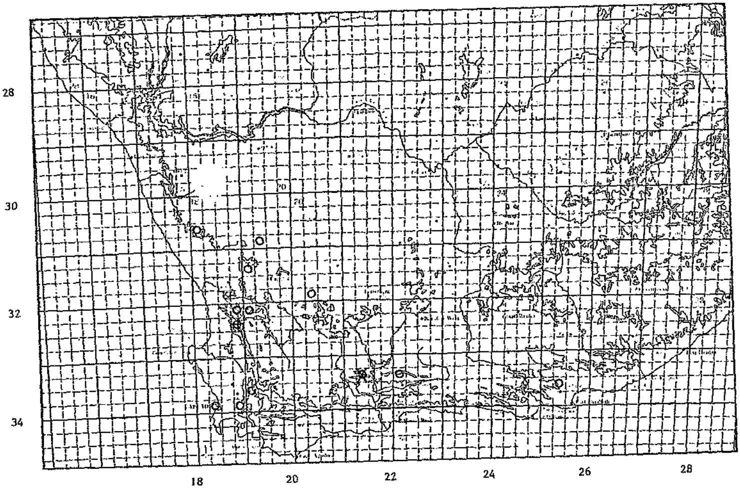


Fig. 20 Distribution of *Xanthoparmelia hypoleia* (O), *X. burmeisteri* (X) and *X. dysprosa* (+).

3-4-29; 3119AC, Top of Vanrhyns Pass, Bokkeveldberg on TMS and soil, alt. 800 m, 768 10-2-4, 768 10-2-5, 768 10-2-16, 768 10-2-19, 768 10-2-23, 772 9-3-3, 772 9-3-7, 772 9-3-8; 3120CD, 12 km ESE of Middelpos, on Beaufort mudstone, alt. 1400 m, 772 4-2-5, 772 4-2-19; 3218BB, Pakhuis Pass near Clanwilliam, Pakhuisberg (Cedarberg), on TMS, alt. 610-670 m, 772 8-3-14pp, 772 8-3-19; 3218BD, 25 km S of Clanwilliam, Olifants river valley, on TMS, alt. 400-600 m, 772 8-1-8pp; 3219AA, top of Pakhuis Pass near Clanwilliam, Pakhuisberg (Cedarberg), on TMS, alt. 880-915 m, 772 8-2-17pp, 772 8-2-28, 768 10-3-10; 3318CD, Top of Table Mountain, on TMS, alt. 900 m, 772 6-1-8; 3318DD, Paarl rock near Paarl, on Cape granite, leg. Miss van Velden (P.A. v.d. Bijl no. 334) TUR-VAIN no 34578; 3319CA, Bainskloof near Wellington, Auf Felsen der höchsten Vrämme, Dr. Wawra, Erdumseglung S.M. Fregatte "Donau" 1868-1871, W no. (1931) 12972 pp; 3321AD, Seven Weeks Poort near Ladismith on TMS, alt. 1000 m, 772 11-3-12, 772 11-3-15, 772 11-3-30, 772 11-3-38, 772 11-3-41; 3322AC, top of Swartberg Pass, 18 km S of Prince Albert, Swartberg, on TMS, alt. 1700 m, 772 11-1-7; 3325CB, Uitenhage, Zeyher (FH., on sheet with the holotype of *P. mutabilis* Tayl., also in BM).

Xanthoparmelia hypomelaena (Vain. ex Lynge) comb. nov.

Plate 16, Fig. 23. (p. 176).

Basionomen: *Parmelia stenophylla* f. *hypomelaena* Vainio ex Lynge (1937) Rev. Bryol. Lichenol., 10: 89.

Holotypus: Cape Province, Ceres, T.B. Leslie, June 1924. (Hb. Vain. 34575) TUR-VAIN 33499!

(Non *X. hypomelaena* (Hale) Hale (1974) Phytologia, 28 (5): 487. Basionomen: *Parmelia hypomelaena* Hale (1967) Bryologist, 70: 416).

Thallus foliose; loosely to moderately adnate; on rock; up to *10 cm across. Lobes mostly* horizontal; very elongate to sublinear; imbricate to highly imbricate; 0.3-2 mm broad; 100-300 µm thick. Upper surface green; glossy to dull; pored epicorticate; commonly faintly to sometimes strongly maculate; *non-isidiate and esorediate. Upper* cortex 25-50 µm, the upper 15-25 µm dark in section due to embedded usnic acid . Algal layer uneven and sometimes broken, 0-50 µm. Medulla 100-200 µm. Reverse cortex 15-30 µm. Reverse surface black; with rhizines absent to moderately abundant.

Apothecia uncommon; when present sparse to moderately abundant; substipitate; up to 6 mm across; shallowly cupped. Hymenium 40-60 µm. Subhymenium 10-20 µm. Exciple 30-60 µm. Ascospores 8-12 µm by 4½-7 µm (few seen).

Pycnia 100-150 µm in mean diameter. Pycnoconidia not seen.

Medulla white or with a faint pink tinge; K+ either rich yellow becoming yellow-orange, or nothing at first then slowly to rapdily becoming bright orange; C-; P+ orange; strongly blue-white fluorescent in UV^{350nm} when the accessory squamatic acid is present.

Chemistry:- Usnic acid in the upper cortex, and either thamnolic acid, or unknown Th-1 with or without squamatic acid, in the medulla.

This is a member of the *X. hypoleia* complex, but differs in chemistry, and is more commonly broader lobed and less strongly maculate, than in any other species in this complex (plate 16). The medullary chemistries cause distinctive colour reactions with K, which are unique *in this complex. X. hypomelaena* is considered to consist of two chemical strains: The southern (type) strain containing thamnolic acid; and the western strain (Fig. 23) containing an unidentified, suspected β-orcinol *meta*-depside, Th-1, *with squamatic acid as an accessory. The overall* thallus habit ranges of the two strains are similar, as are their chemistries, but they are treated as one species for the present, even though they appear to differ in distribution.

Faintly maculate and broad lobed specimens of this species may resemble some Karoo specimens of *X. tasmanica*, but the latter contains *salazinic acid, and is K+ yellow becoming blood-red.*

Specimens examined (Specimens followed by * contain rhamnolic acid, all the others contain Th-1): 3218BD, 26 km S of Clanwilliam, Olifants river valley, on TMS, alt. 400-600 m, 772 8-1-8b pp.; 3219AA, 34 km NE of Clanwilliam, Klipfonteinrant, on TMS, alt. 300-460 m, 768 10-3-10, 768 10-3-11; 3219AA, 20 km ENE of Clanwilliam, top of Pakhuis Pass, on TMS, alt. 880-915 m, 772 8-2-9, 772 8-2-19pp; 3319AD, Ceres, T.B. Leslie, June 1924, TUR-VAIN 33499 * ; 3321AD, Seven Weeks Poort near Ladismith. on TMS, alt. 915-945 m, 772 11-3-9 *.

Xanthoparmelia hypoprotocetrarica (Kurok. et Elix) Hale

Plate 15 A, B, and C; Fig. 21. (p. 166).

Hale (1974) Phytologia, 28 (5): 487.

Parmelia hypoprotocetrarica Kurokawa et Elix (1971)

J. Jpn. Bot., 46 (4): 113-114, Plate V, fig. 1.
Holotypus: Australia. Australian Capital Territory:
Coppins' Crossing. Growing on Porphyry boulders. J.A.
Elix, no. 101, 1970 (TNS! Isotypus: MEL).

Thallus as in *X. hypoleia* (Nyl.) Hale, except more commonly collected with lobes in a subascending condition, but also sometimes in a sublinear lobed, highly imbricated condition.

Medulla white or faint rose; K+ faint yellowish sometimes becoming pale wine rose or K-; KC no change from the K reaction or a momentary slight enhancement; C+ faint to pale yellow, or C+ fleeting yellow or pale orange, fading to pale yellow; P-.

Chemistry:- Usnic, hypoprotocetraric, and possibly 4-O-methylhypoprotocetraric acids present.

Most closely related to *X. hypoprotocetrarica* is probably *X. notata* (Kurok.) Hale (Kurokawa et al., 1971), containing notatic and 4-O-methylhypoprotocetraric acids, and found in Australia, but not known from the Cape. *X. hypoprotocetrarica* may in future be found to be a chemical variant of *X. notata* since they both have been found to contain 4-O-methylhypoprotocetraric acid. In the present collection *X. hypoprotocetrarica* was found as far north as Vanrhyns Pass and as far east as Meiringspoort, on the margins of the Karoo. Some faintly- or emaculate specimens of this species may be mistaken for some foliose specimens of *X. perspersa* with black undersurfaces, but highly imbricate linear lobes or thick, subascending lobes are indicative of *X. hypoprotocetrarica*. This species is also closely related to *X. columnata*, but the latter species is characterised by closely appressed discrete to contiguous, convex lobes a habit somewhat reminiscent of part of the habit range of the unrelated *X. exornata*.

Specimens examined: 3119AC, 42 km NE of Vanrhynsdorp, Vanrhyns Pass, on TMS, alt. 460-610 m, 768 10-1-7, 768 10-1-8, 768 10-1-9, 768 10-1-14; 3218BB, 11 km NE of Clanwilliam, Pakhuis Pass, on TMS, alt. 610-670 m, 772 8-3-4, 772 8-3-19; 3218BD, 26 km S of Clanwilliam, Olifants river valley, on TMS, alt. 400-600 m, 772 8-1-17; 3219AC, 12 km WNW of Algeria, Rondegat river valley, on TMS, alt. 760-915 m, 768 11-1-2; 3318CD, Cap. B. Spei, supra terram sabulosam, in mte. Tabularis, Wilms, H-NYL pm 1752; 3319CA, Bainskloof (near Wellington) Auf Felsen der höchsten Vrämme, Dr. Wawra, Erdumseglung S.M. Fregatte "Donau" 1868-1871, W (1931) 12972 p.p.; 3322AC, 18 km S of Prince Albert, top of Swartberg Pass, on TMS, alt. 1700 m,

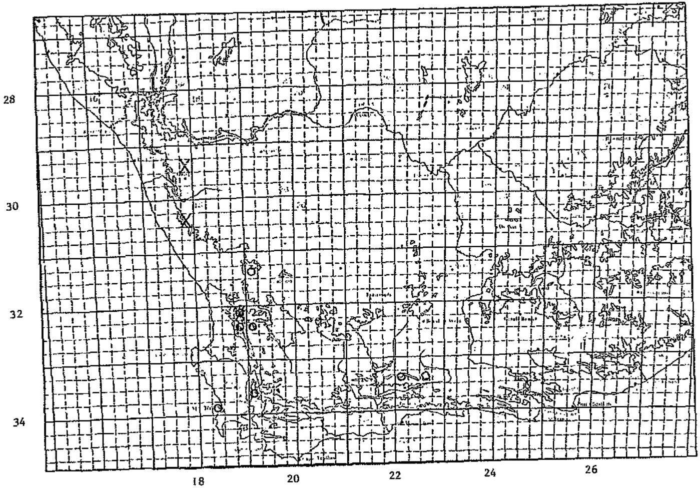


Fig. 21 Distribution of *Xanthoparmelia hypoprotocetrarica* (O) and *X. columnata* (X).

772 11-1-15; 3322BC, 18 km N of De Rust, Meiringspoort, on Bokkeveld shale, alt. 640-730 m, 772 14-1-4p.p., 772 14-1-7, 772 14-1-14, 772 14-1-22, 772 14-1-28.

Xanthoparmelia hyporhytida (Hale) Hale

Plate 19C and D.

Hale (1974) Phytologia, 28 (5): 488.

Parmelia hyporhytida Hale (1971) Bot. Not., 124: 349-352, fig. 3A.

Holotypus: Cape Province, Div. Clanwilliam, on rocks North of Clanwilliam. Leg. L. Kofler 15-9-1963 (LD! Isotypus: US).

Thallus foliose to subfruticose; loosely to moderately adnate; on rock; up to 8 cm across. Lobes elongate to sublinear; uniformly appressed to subascending; contiguous to highly imbricate, 0.3-3 mm broad; 100-300 µm thick. Upper surface green to yellow-green; dull to sometimes glossy; pored epicorticate; faintly- to non-maculate, non-isidiate and esorediate. Under surface pale brown to often black at the lobe tips, or largely black with a pale brown interior; smooth to highly wrinkled; sparsely rhizinate, often coarse or fused together to form holdfasts.

Medulla faint pink to pale dirty yellowish; K+ yellow turning blood-red, K+ yellow-orange turning blood-red; or K+ yellow-orange *darkening slightly on drying*; C-; P+ yellow-orange to orange. Chemistry:- Usnic, salazinic acids with or without the "chalybaei unknown" present.

This species was collected only once on the western margin, but appears to be more typical of the Namib desert than the Karoo, where it is essentially absent. The species may be related to *X. chalybaeizans*, but differs in being subfruticose or in having subascending lobes, and in lacking the "chalybaeizans unknown" in part.

Specimens examined: 2214DA, Swakopmund, on stones, Alex von Holy 8/77; 3218BB, 11 km NE of Clanwilliam, Pakhuis Pass, on TMS, alt. 610-670 m, 772 8-3-14pp.

Xanthoparmelia ianthina sp. nov.

Plate 26D, Fig. 18. (p. 147).

Thallus ut in *Xanthoparmelia endomiltodes* (Nyl.) Hale, sed vice acidi salazinici, materiam ignotam continente differt.

Holotypus: 3218BD, 26 km S of Clanwilliam, Olifants river valley, on Table Mountain sandstone, alt. 400-600 m, F. Brusse 772 8-1-15, 8/2/77.

Isotypus: 772 8-1-4.

Thallus as in *Xanthoparmelia endomiltodes* (Nyl.) Hale, but differs in containing unknown substances, instead of salazinic acid.

Medulla violet; K+ purple.

Chemistry: Th-1, Th-2 and 4 pigments, endo-1 to endo-4, present.

This species is similar to *X. endomiltodes*, but too few specimens were seen to note any significant morphological tendencies. It contains the same pigments, distributed throughout most of the medulla, as the latter species. The species contains Th-1 and Th-2, suspected β-orcinol *meta*-depsides, whereas the β-orcinol depsidone, salazinic acid, is present in *X. endomiltodes*. Th-1 has also been found in a strain of *X. hypomelaena*, a completely unrelated species. *X. endomiltodes* and *X. ianthina* also differ in distribution, the former being present on the southern margin, and the latter being present in the southern portion of the western margin (Fig. 18). (See *X. endomiltodes* for affinities to other species)

Specimens examined: 3119AC, 42 km NE of Vanrhynsdorp, Vanrhyns Pass, on TMS, alt. 460-610 m, 768 10-1-15; 3218BD, 26 km S of Clanwilliam, Olifants river valley, on TMS, alt. 400-600 m, 772 8-1-4, 772 8-1-15.

Xanthoparmelia leptoplaca (Zahlbr.) nov. comb.

Plate 33; Fig. 22. (p. 171).

Basionomen: *Lecanora leptoplaca*. Zahlbrückner (1932) Ann. Crypt. Exot., 5: 249 (non Nylander apud O.-J. Richard (1877) Catal. Lich. Deux - Sèvres, p. 28; non Zahlbrückner apud Magnusson et Zahlbrückner (1944) Ark. Bot. 31A (6): 64) Holotypus: Kapland, Laingsburg (grosse Karroo), Sandsteinfelsen, c. 700 m. Leg. J. Brunnthaler 11.11.1909. W (1936) 626!

Squamarina leptoplaca (Zahlbr.) Dodge (1971) Nova Hedwigia Beih., 38: 32-33.

Thallus crustose to subcrustose; on rock; up to 4 cm across; areolate in the centre, lobate on the margins. Lobes elongate to very elongate; discrete to contiguous; 0.2-1.3 mm broad; up to 6 mm long to the first complete transverse fissure; 60-200 µm thick. Upper surface yellow-green; minutely felty and often coarse pruinose at the lobe tips; with a rudimentary epicortex; neither isidiate nor sorediate. Upper cortex 15-30 µm, the upper 10-20 µm with usnic acid. Algal layer 20-40 µm. Medulla 10-140 µm. Lower cortex 5-15 µm. Under surface pale brown; erhizinate or with rudimentary rhizines.

Apothecia common; when present scarce to abundant; innate, emergent or somewhat adnate; up to 1.5 mm across. Hymenium surface livid brown to often black. Hymenium 40-60 µm. Subhymenium 10-20 µm. Exciple 20-60 µm. Ascospores 8 per ascus, 6½-11½ µm by 4-6½ µm (108/5). Pycnia 80-150 µm in mean diameter. Pycnoconidia 8-12 µm long.

Medulla: white or pale pink; K+ yellow turning red or blood-red; C-; P+ yellow to orange.

Chemistry:- Usnic acid and rarely atranorin in the upper cortex, salazinic acid with norstictic acid as an accessory in the medulla.

This is a typical Karoo species, but has not been found in the Northern Karoo (1.4.1). It is also absent on the southern and western margins. *X. leptoplaca* is similar to (the present concept of) *X. adhaerens* in morphology and habit range, but differs in distribution and chemistry. *X. adhaerens* contains the stictic acid suite and is present on the Karoo margins only. These two species have been found together at Perdepoort near Willowmore, but otherwise have exclusive distributions.

The habit range of *X. leptoplaca* is relatively conservative. In many cases the thallus can be regarded as crustose, with only the very tips of the marginal lobes with well defined lower cortices. At moister sites the thalli may be more robust, with a larger area of cortex beneath the marginal lobes. In the latter case, the apothecia are inclined to be adnate and larger, more often. However, separation of these states into two taxa is a futile exercise, and in all cases, more robust states have been found together with less robust specimens, (but not vice versa).

Specimens examined: 2923DC, Strydenburg, on dolerite, alt. 1080-1110 m, 768 5-2-6; 2923DD, 19 km NE of Strydenburg, Elands Berg, on dolerite, alt. 1190-1280 m, 768 5-1-3, 768 5-1-4; 3021DD, 15 km W of Carnarvon, on dolerite, alt. 1220-1370 m, 768 7-1-11; 3022CC, 8 km N of Carnarvon, on dolerite, alt. 1200-1250 m, 772 16-1-1; 3022CD, 18 km NE of Carnarvon, Kareebospoort, alt. 1280-1310 m, 768 6-5-6, (dolerite), 768 6-5-8 (Ecca

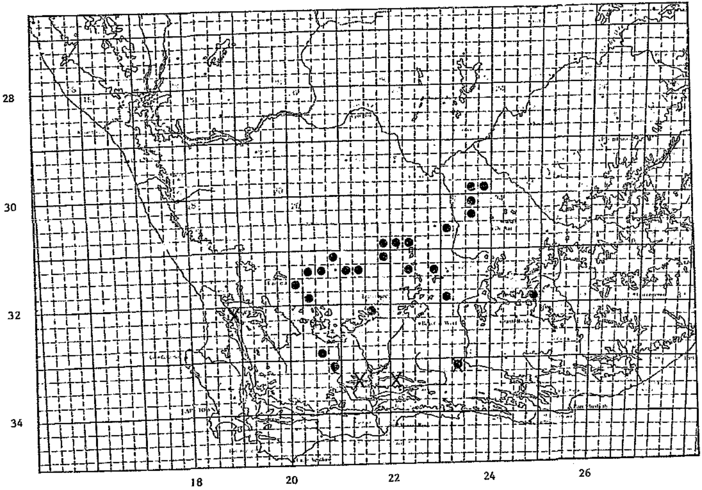


Fig. 22 Distribution of *Xanthoparmelia leptoplaca* (●) and *X. adhaerens* (X).

shale/sandstone); 3023BA, 22 km S of Strydenburg, on dolerite, alt. 1100-1130 m, 768 5-3-6; 3023BC, 16 km NNE of Britstown, on dolerite, alt. 1160-1190 m, 768 5-5-2, 768 5-5-5; 3023CA, 32 km W of Britstown, on dolerite, *1140-1160 m, 768 6-2-4; 3120AD, 53 km W of Williston,* on dolerite, alt. ± 1070 m, 772 10-1-6; 3120BB, 24 km NW of Williston, on dolerite, alt. 1070-1220 m, 768 7-5-5 3120BC, 34 km W of Williston, Jan Swartsberge, on dolerite, 1170-1200 m elev., 772 10-2-2pp; 3120CA, 48 km NW of Middelpos, on dolerite, alt. 915-1220 m, 772 4-1-3, 772 4-1-4, 772 4-1-11, 772 4-1-12; 3120CD, 12 km ESE of Middelpos, on Beaufort mudstone, 772 4-2-10, 772 4-2-11pp; 3121AC, 13 km ENE of Williston, Soutpanspoort, on dolerite, alt. 1160-1170 m, 768 7-4-1, 768 7-4-3pp, 768 7-4-4, 768 7-4-5; *3121AD, 48 km ENE of Williston, on Ecca siltstone, alt.* 1140-1160 m, 768 7-3-6, 768 7-3-7; 3121BB, 40 km WSW of Carnarvon, Klipheuvels, on dolerite, alt. 1310-1330 m, 768 7-2-2; 3122AD, 3 km NNW of Loxton, on Beaufort mudstone, alt. 1370-1525 m, 772 15-4-11; 3122BD, 27 km W of Victoria West, Gap Kop, alt. ± 1370 m, 772 15-3-4 (on dolerite), 772 15-3-9pp (on dolerite), 772 15-3-10 (on Beaufort mudstone), *772 15-3-22* (on dolerite); 3123CC, Three Sisters, alt. 1140-1240 m, 768 12-4-10 (on Beaufort siltstone), 768 12-4-11 (on dolerite), 768 12-4-8pp (on dolerite); *3124DD, Lootsberg Pass, half way between Graaff-*Reinet and Middleburg, on Beaufort mudstone, alt. 1800 m, 772 15-2-7pp, 772 15-2-6, 772 15-2-26; 3220DC, 34 km N of Matjiesfontein, Turck's Pass, on Ecca shale, alt. 1200-1235 m, 772 4-4-10; 3221BA, 16 km SSE of Fraserburg, Zaai Klipheuvels, on dolerite, alt. 1400-1430 m, 772 10-4-1, 772 10-4-3, 772 10-4-5; 3221BA, 37 km SSE of Fraserburg, Teekloof, on Beaufort mudstone, *alt.* 1160-1220m, 772 10-5-1, 772 10-5-2pp, 772 10-5-6; 3320BB, Kapland, prope Laingsburg (Grosse Karroo) c. 700 msm ad saxa arenaria (J. Brunnthaler, *11/11/1909) W (1934) 626!;* 3323AD, 14 km N of Willowmore, Perdepoort, on quartzitic Witteberg rock, alt. 850-880 m, 772 14-3-10.

Xanthoparmelia leucostigma sp. nov.

Plate 19A and B.

Thallus foliaceus; modice vel arte adnatus; in rupibus. Lobi elongati vel valde elongati; plani vel convexi; aequaliter appressi; contigui; 0.5-3 mm lati; 100-300 µm crassi. Pagina supera viridis; impolita; epicortice poroso; albomaculata; isidiis sorediisque destituta. Cortex superus 15-70 µm crassus. Stratum algarum irregulare, 4 0 µm crassum. Medulla 60-200 µm crassa. Cortex inferus 15-30 µm crassus. Pagina infera eborina vel pallide fusca; modice rhizinata, rhizinis grossis.

Apothecia parce vel modice numerosa; substipitata; usque ad 3 mm lata. Hymenium 40-60 µm altum. Subhymenium 10-15 µm crassum. Excipulum 20-40 µm crassum, Ascosporae octonae, 6-9½ µm X 4½-5½ µm. Pycnia 100-200 µm diametris. Pycnoconidia 5-8 µm longa.

Medulla alba; K-; C+ dilute rosea; P-. Acidum usnicum in cortice superiore, et in medulla acidum gyrophoricum continens.

Holotypus: South Africa, Cape Province, 3322BC, 18 km N of De Rust, Meiringspoort, F. Brusse 772 14-1-17, 14/2/77. Isotypus: 772 14-1-13, 14/2/77.

Thallus foliose; moderately to tightly adnate; on rock. Lobes elongate to very elongate, plane to convex; evenly appressed; contiguous; 0.5-3 mm broad; 100-300 µm thick. Upper surface green; white maculate; dull; pored epicorticate; non isidiate and esorediate. Upper cortex 15-70 µm thick. Algal layer uneven, 40-80 µm thick. Medulla 60-200 µm thick. Lower cortex 15-30 µm thick. Undersurface ivory to pale fuscous; moderately rhizinate, with the rhizines coarse.

Apothecia sparsely or moderately abundant; substipitate; up to 3 mm across. Hymenium 40-60 µm. Subhymenium 10-15 µm thick. Exciple 20-40 µm thick. Ascospores eight, 6 µm X 4½-5½ µm.

Pycnia 100–200 µm in diameter. Pycnoconidia 5–8 µm long.

Medulla white; K−; C+ pale pink; P−. Containing usnic acid in the upper cortex and gyrophoric acid in the medulla.

This species is rare in the present collections (known only from the type collection), but appears to be similar to *X. exornata*, from which it differs in containing gyrophoric acid (rather than the salazinic acid of the latter species.

Xanthoparmelia molliuscula (Ach.) Hale

Plate 24A; Fig. 23. (p. 176).

Hale (1974) Phytologia, 28 (5): 488.

Parmelia molliuscula Acharius (1810) Lichenographia Universalis, p. 492.

Holotypus: (fide Hale (1968)) Caput Bonae Spei, Thunberg (UPS, isotypus H).

Parmelia thamnidiella Stirton (1877) *Trans. Glas. Soc. Field Nat.*, *5*: *213–214*.

Holotypus: (Hale, 1968) So. Africa, Somerset East: Prof. P. MacOwan (BM!). Isotypi : Ad rupes basalticus summi mts. Boschberg prope Somerset East in CBS, LXXVI, MacOwan (PRE!); On the ground, S. Africa, Cave Mountain, J.H. McLea (BM!).

Parmelia conspersa var *thamnidiella* (Stirt.) Stizenberger (*1890*) Ber. Thatigk. St. Gall. naturwiss. Ges., *1888/89*: *153*.

Parmelia conspersa f. *molliuscula* (Ach.) Wainio (1899) Természetr. Füzetek, 22: 280.

Parmelia steineri Gyelnik (1938) Sydowia Ann. Mycol., 36 (4): 289.

Holotypus: South Africa, Wolseley, on the ground. Leg. A.E. v.d. Byl (P.A. v.d. Bijl 1141) W (1935)–!

Pseudevernia molliuscula (Ach.) Dodge (1959) Ann. Mo. Bot. Gard., 46 (2): 183. (Hale, 1968).

Pseudevernia thamnidiella (Stirt.) Dodge (1959) Ann. Mo. Bot. Gard., 46 (2): 182. (Hale, 1968).

Thallus foliose to fruticose; moderately to loosely adnate; on soil and rock; up to 5 cm across; fragile. Lobes versatile in habit, dorsiventral to terete; elongate to linear; imbricate, highly imbricate to very open in structure and fruticose; 0.15-2 mm broad; 80-400 µm thick. Upper surface often glossy at the lobe ends, but dull in the interior; pored epicorticate; emaculate; esorediate, and non-isidiate. Undersurface not present on terete portions of lobes, brown to pale brown; sparsely to moderately rhizinate, rhizines small to moderate in size.

Apothecia not seen, presumed to be sporadic. Pycnia 100-200 µm in mean diameter. Pycnoconidia 5-8 µm long.

Medulla white or tinged rose; K+ yellow sometimes becoming yellow-orange; C-; P+ yellow to yellow-orange.

Chemistry:- Usnic acid sporadically with atranorin in the upper cortex. Stictic acid, variable amounts of constictic acid and St-1, with norstictic acid as an accessory, in the medulla.

This species is very rare, if at all present in the Karoo, but is known from as far north as Garies on the western margin, and as far east as Somerset East on the southern margin. The amount of terete lobe relative to dorsiventral lobe varies from specimen to specimen, but thalli wholly composed of dorsiventral lobes were not collected. Sometimes the dorsiventral-terete transition is so abrupt, that the terete portions may be mistaken for coarse isidia.

The only other species that could be mistaken for this distinctive species is *X. amphixanthoides* (J. Stein. et Zahlbr.) Hale, containing

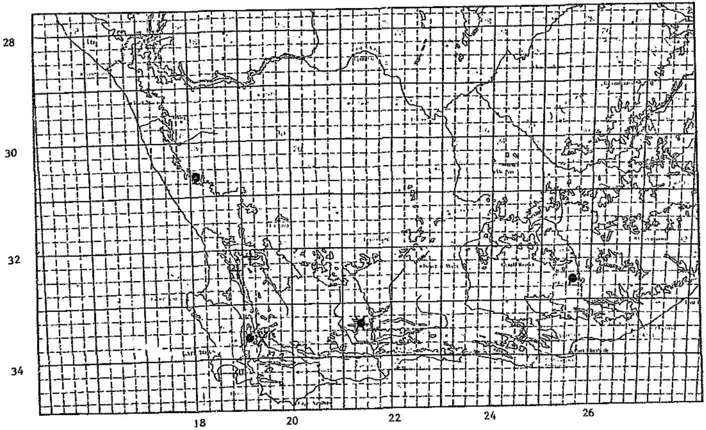


Fig. 23 Distribution of *Xanthoparmelia molliuscula* (●) and *X. hypomelaena*, thamnolic acid strain (X), Th-1 strain (+).

salazinic acid and the "chalybaeizans unknown" in the medulla. The latter species is not present in the Karoo collections. The taxonomic status of both these species is beyond the scope of the present collections.

Specimens examined: *3018CA*, 20 km SSE of Garies, on gneiss and soil, alt. 360-380 m, 772 9-1-35, 772 9-1-37; *3225DA*, Somerset East, on dolerite and an ustated substrate, Prof. P. MacOwan (BM); 3319AC, Wolseley, on the ground, A.E. v.d. Byl (W); 3321AD, Seven Weeks Poort near Ladismith, on TMS, alt. 915-945 m, 772 11-3-29.

Xanthoparmelia persperea (Stiz.) comb. nov.

Plate 26A, and B; 28; 29; Fig. 24. (p. 181).

Basionomen: *Parmelia persperea* Stizenberger (1890) Ber. Thatigk. St. Gall. naturw. *Ges.*, 1888/90: 152.

Holotypus: Supra saxa arenaria in fastigio septentrionali montis Leonis - 2000 m - prope Kapstadt in Promontorio *Bonae* Spei. MacOwan. ZT!

Parmelia domokosii Gyelnik (1938) Sydowia Ann. Mycol., 36 (4): 227.

Holotypus: South Africa, Laingsburg, on stone. Leg. P.A. v.d. Bijl no. *1091*. *W (1935)* !

Parmelia encrustans Hale (1971) Bot. Not., 124: 348-349

Fig. 2A.

Holotypus: Cape *Province*, Distr. Namaqualand, on rocks between O'okiep and Springbok.

O. Almborn 4792, 15/9/1953. (LD! Isotypus : US)

Parmelia subdomokosii Hale (1971) Bot. Not., 124: 353-354

Fig. 3D.

Holotypus: Africa australis, prov. Cape, dist.
Swellendam. 7 miles W of Heidelburg, C.P. Small hill
Exposed To the sun. Leg. O.A. Höeg, 12/6/1929.
(TRH! Isotypi : LD, US.)

Xanthoparmelia domokosii (Gyel.) Hale (1974) Phytologia, 28 (5): 487.

Xanthoparmelia encrustans (Hale) Hale (1974) Phytologia, 28 (5): 487.

Xanthoparmelia subdomokosii (Hale) Hale (1974) Phytologia, 28 (5): 489.

(c.f. *Xanthoparmelia dissensa* (Nash) Hale (Nash, 1973), a North American species)

Thallus subcrustose to foliose; subcrustose to moderately adnate; on rock; up to 10 cm across. Lobes elongate to very elongate; evenly appressed; rarely somewhat convolute; contiguous; 0.2-4 mm broad; 100-500 μm thick. Upper surface yellow-green to green; emaculate; minutely felty to coarse pruinose at the lobe tips of most subcrustose specimens, dull to glossy at the lobe tips of most foliose specimens; with the epicortex rudimentary to pored; non-isidiate, and esorediate. Upper cortex 15-30 μm. Algal layer 20-70 μm. Medulla 60-430 μm. Lower cortex 5-15 μm. Lower surface pale brown to black; with rhizines rudimentary to moderate sized; rhizines never abundant.

Apothecia very frequent; when present, sparse to very abundant; sessile to substipitate; up to 1 cm across; plane to shallowly cupped. Hymenium 40-60 μm high. Subhymenium 5-20 μm thick. Exciple 20-40 μm thick. Ascospores 8 per ascus, 6½-12 μm X 4-7 μm (255/9). Pycnia 50-150 μm in mean diameter. Pycnoconidia 5-10 μm long.

Holotypus: Africa australis, prov. Cape, dist.
Swellendam. 7 miles W of Heidelburg, C.P. Small hill
Exposed To the sun. Leg. O.A. Höeg, 12/6/1929.
(TRH! Isotypi : LD, US.)

Xanthoparmelia domokosii (Gyel.) Hale (1974) Phytologia, 28 (5): 487.

Xanthoparmelia encrustans (Hale) Hale (1974) Phytologia, 28 (5): 487.

Xanthoparmelia subdomokosii (Hale) Hale (1974) Phytologia, 28 (5): 489.

(c.f. *Xanthoparmelia dissensa* (Nash) Hale (Nash, 1973), a North American species)

Thallus subcrustose to foliose; subcrustose to moderately adnate; on rock; up to 10 cm across. Lobes elongate to very elongate; evenly appressed; rarely somewhat convolute; contiguous; 0.2-4 mm broad; 100-500 µm thick. Upper surface yellow-green to green; emaculate; minutely felty to coarse pruinose at the lobe tips of most subcrustose specimens, dull to glossy at the lobe tips of most foliose specimens; with the epicortex rudimentary to pored; non-isidiate, and esorediate. Upper cortex 15-30 µm. Algal layer 20-70 µm. Medulla 60-430 µm. Lower cortex 5-15 µm. Lower surface pale brown to black; with rhizines rudimentary to moderate sized; rhizines never abundant.

Apothecia very frequent; when present, sparse to very abundant; sessile to substipitate; up to 1 cm across; plane to shallowly cupped. Hymenium 40-60 µm high. Subhymenium 5-20 µm thick. Exciple 20-40 µm thick. Ascospores 8 per ascus, 6½-12 µm X 4-7 µm (255/9). Pycnia 50-150 µm in mean diameter. Pycnoconidia 5-10 µm long.

Medulla white; K-, or K+ pale yellowish to pale wine red or pale purple; C+ pale yellow sometimes an initial fleeting yellow or pale orange; KC+ wine rose or orange; P-; sometimes, (often in foliose specimens with pale under surfaces) a yellow-orange colour on the lower cortex, which is K+ dirty mauve or violet.

Chemistry:- Usnic acid in the upper cortex. The medulla contains large amounts of hypoprotocetraric and 4-O-demethylnotatic acids, but the relative concentrations of these two substances vary widely. Most specimens contain appreciable amounts of both. Some specimens containing large amounts of 4-O-demethylnotatic acid and only traces of, if any, hypoprotocetraric acid, have been found to contain traces to small amounts of notatic acid (e.g. 772 4-4-7, 772 4-4-8, 772 4-4-9, 772 15-4-4, 772 15-4-7pp, 772 15-4-8, 772 15-4-9). On the other hand, some specimens with major amounts of hypoprotocetraric and little or no 4-O-demethylnotatic acid, have been found to contain small amounts of 4-O-methylhypoprotocetraric acid. A single specimen (772 14-2-4) had 4-O-methylhypoprotocetraric acid in its medulla (tentative) together with two unknowns FB-1 and FB-2, and the usual hypoprotocetraric and 4-O-demethylnotatic acids were completely absent. Unknown Q-1 (Culberson and Hale, 1973) occurs sporadically in this taxon, and some other trace substances detected, could not be identified. The yellow-orange pigment, skyrin, is often present on the lower cortex of foliose specimens which are pale brown beneath.

This concept of the species is broader than has hitherto been accepted, varying from subcrustose to foliose. While it is true that most broad lobed specimens are dull to glossy, and all subcrustose specimens are minutely felty to coarse pruinose, on the upper surface, a few broad lobed specimens are minutely felty to coarse pruinose. Specimens of intermediate lobe size are just as often dull to glossy as they are coarse pruinose, with a surface texture of an undecided nature being quite common as well. All attempts to segregate the available specimens int good morphological taxa proved fruitless, and it seemed best to regard these taxa as forms of a single species. However, the various forms are not equally distributed, and two forms have often been found growing side by side. The colour of the under surface could also not be correlated with any particular thallus habit, rock type, or area, although most specimens are either black or pale brown below.

X. worcesteri is similar to *X. perspersa*, in the range of habits displayed, but the subcrustose habit of the former species (a) is restricted to the Central Karoo (1.4.2) (b) has only been found with a pale under surface and (c) is infrequent. On the other hand, subcrustose forms of *X. perspersa* are frequent and more widespread, but centred on the western and southern margins, and become infrequent in the eastern part of the Karoo. Both black and pale brown undersurface forms are known for the subcrustose part of *X. perspersa*. *X. worcesteri* contains lecanoric acid, the main difference between these two species. *X. chalybaeizans* is also comparable to *X. perspersa*, but subcrustose forms have been found only on the western margin, and the reverse surface is always pale brown. However, the overall habit range of *X. chalybaeizans* is significantly different, as is the chemistry, the basis of the taxonomic separation.

The theoretical isidiate counterparts of this species could be considered to be *X. neocongensis* (Hale) Hale and *X. weberi* (Hale) Hale, both of which are probably present in the eastern half of southern Africa, but are poorly known at present. *X. weberi* is the commonest *Xanthoparmelia* in the Sonoran desert of North America (Nash, 1974a).

Other Karoo Xanthoparmeliae containing hypoprotocetraric acid belong to the *X. hypoleia* group, and are not normally mistaken for this species.

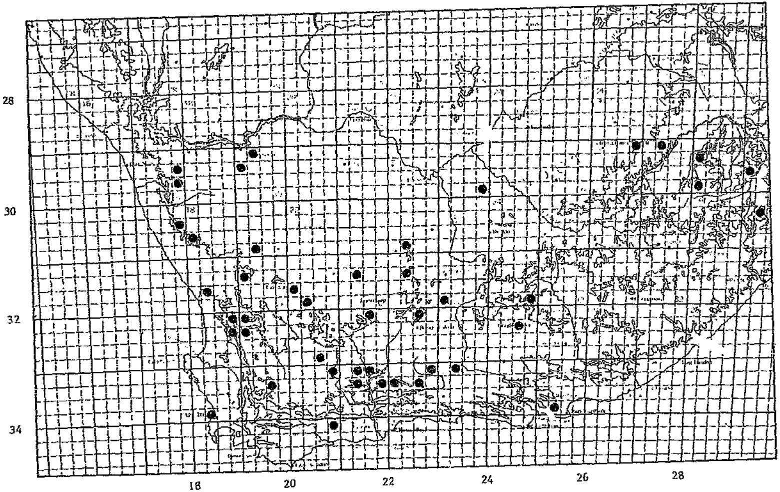


Fig. 24 Distribution of *Xanthoparmelia perspersa*.

Specimens examined: 2917BD, 29 km N of Springbok, Vrieskloofhoogte/ Ratelpoort, on white gneiss, alt. 880-940 m, 772 2-4-3, 772 2-4-11, 772 2-4-15, 772 2-4-25; 2917DB, between O'okiep and Springbok, on rocks, O. Almborn 4792, 15/9/1953, LD; 2919AB, 8 km ENE of Pofadder, on granitic rock, alt. 915-1070 m, 768 [illegible]-3-1; 2919AC, 40 km SW of Pofadder, Namiesberg on quartzo-felspathic rock, alt. 960-1040 m, 772 3-2-4, 772 3-2-9; 2923DD, 19 km NE of Strydenburg, Elands berg, on dolerite, alt. 1190-1280 m, 768 5-1-11, 768 5-1-12, 768 5-1-19; (2926BB & BD, Mt. Thaba 'Nchu, District Thaba 'Nchu, O.A. Höeg, 12/8/1929 (TRH); 2927AB, 5 miles W of Ladybrand, 2000 m, Maas Geesteranus 6524, (L); 2928AC, Blue Montain Pass, Distr. Marakabei, L. Kofler 2/6/63, (LD)); 2928CC, Maletsunyane Falls near Semonkong, on basalt, 7611 30-5; (2929CA, Black Mountains, Distr. Qachas Nek, L. Kofler, 9/2/63, (LD); 2930DC, Botha's Hill (Natal), distr. Camperdown, O.A. Höeg, 15/8/29, (TRH)); 3017BD, 19 km S of Kamieskroon, Karkams/Garagams, on granitic rock, alt. 760-790 m, 772 9-2-3, 772 9-2-5, 772 9-2-13, 772 9-2-14, 772 9-2-17, 772 9-2-19pp; 3018CA, 20 km SSE of Garies, on gneiss, alt. 360-380 m, 772 9-1-5, 772 9-1-9, 772 9-1-15, 772 9-1-18, 772 9-1-22, 772 9-1-23; 3019CD, 6 km S of Louriesfontein, Kubiskouberg, on dolerite, alt. 880-900 m, 772 3-4-1; 3022CD, 51 km SW of Vosburg, Elandsfonteinkop, on dolerite, alt. 1310-1400 m, 768 6-4-1; 3022CD, 18 km NE of Carnarvon, Kareebospoort, on dolerite, alt. 1280-1310 m, 768 6-5-1, 768 6-5-2, 768 6-5-5; 3029AD, Natal, District Mount Currie, 18 km NW of Kokstad, Droewig area, Weltevrede farm, on Beaufort mudstone, alt. 1460 m, 781-36; (3118CB, Koekenaap, district Vredendal, L. Kofler 16/9/1963 (LD)); 3119AC, 42 km NE of Vanrhynsdorp, half-way up Vanrhyns Pass, on TMS, alt. 460-510 m, 768 10-1-10pp, 768 10-1-13, 768 10-1-19 to 22; 3119AC, 45 km NE of Vanrhynsdorp, top of Vanrhyns Pass, on TMS, alt. 800 m, 768 10-2-11, 768 10-2-14, 768 10-2-21; 3120CA, 48 km NW of

Middelpos, on dolerite, alt. 915-1220 m, 772 4-1-1, 772 4-1-2, 772 4-1-5, 772 4-1-7, 772 4-1-14; 3120DD, 12 km ESE of Middelpos, on Beaufort mudstone, alt. 1250-1280 m, 772 4-2-10pp, 772 4-2-11pp, 772 4-2-18, 772 4-2-20, 772 4-2-21, 772 4-2-22; 3121AD, 48 km ENE of Williston, on Ecca sandstone, alt. 1140-1160 m, 768 7-3-1; 3122AD, 3 km NNW of Loxton, on Beaufort mudstone, alt. 1370-1525 m, 772 15-4-1pp, 772 15-4-2, 772 15-4-3, 772 15-4-4, 772 15-4-6, 772 15-4-7pp, 772 15-4-8, 772 15-4-9, 772 15-2-13, 772 15-4-14, 772 15-4-15, 772 15-4-16, 772 15-4-18, 772 15-4-19, 772 15-4-21, 772 15-4-23; 3123CC, Three Sisters, on dolerite, alt. 1140-1240 m, 768 12-4-8; 3124DD, Lootsberg Pass, half-way between Graaff-Reinet and Middleburg, on Beaufort mudstone, alt. 1800 m, 772 15-2-3, 772 15-2-6pp, 772 15-2-20, 772 15-2-22, 772 15-2-23, 772 15-2-24, 772 15-2-25pp, 772 15-2-26; 3218BB, 11 km NE of Clanwilliam, Pakhuis Pass, on TMS, alt. 610-670 m, 772 8-3-12; 3218BD, 26 km S of Clanwilliam, Olifants river valley, on TMS, 400-600 m, 772 8-1-1pp, 772 8-1-2, 772 8-1-3, 772 8-1-10; 3219AA, 34 km NE of Clanwilliam, Klipfonteinrant, on TMS, alt. 300-460 m, 768 10-3-2; 3219AA, 20 km ENE of Clanwilliam, top of Pakhuis Pass, on TMS, alt. 880-915 m, 772 8-2-2, 772 8-2-3, 772 8-2-4, 772 8-2-6pp; 3219AC, 12 km WNW of Algeria, Rondegat river valley, on TMS, alt. 760-915 m, 768 11-1-3, 768 11-1-7; 3220DC, 34 km N of Matjiesfontein, Turck's Pass, on Ecca shale, alt. 1200-1235 m, 772 4-4-6, 772 4-4-7, 772 4-4-8, 772 4-4-9; 3221BA, 37 km SSE of Fraserburg, Teekloof, on Beaufort mudstone, alt. 1160-1220 m, 772 10-5-2, 772 10-5-3, 772 10-5-5, 772 10-5-13pp; 3222BA, 13 km N of Beaufort West, Molteno Pass, on dolerite, alt. 1400-1460 m, 768 12-3-2, 768 12-3-3; 3224BC, 6 km SW of Graaff-Reinet, Munnikspoort, on Beaufort mudstone, alt. 810-825 m, 772 15-1-2, 772 15-1-3 772 15-1-4, 772 15-1-5, 772 15-1-6, 772 15-1-7, 772 15-1-8, 772 15-1-10, 772 15-1-11; 3318CD, Supra saxa arenaria in fastigio septentrionalis, Montis Leonis - 2000 m - (=-700 m-) prope Kapstadt in Promontorio Bonae Spei. MacOwan. ZT; (3318CD, Dist.

Cape, Camps Bay, near Caltex garage, Almborn, 4396, LD); 3319BC, 46 km ENE of Ceres, on Bokkeveld shale, ± 900 m, 768 11-3-5, 768 11-3-6, 768 11-3-7, 768 11-3-8, 768 11-3-9, 768 11-3-10; 3320BB, South Africa, Laingsburg, on stone, Leg. P.A. v.d. Bijl no. 1091 W; 3321AB, 42 km E of Laingsburg, on Ecca shale, alt. 610-760 m, 768 12-1-1; 3321AD, Seven Weeks Poort near Ladismith, on TMS, alt. 915-945 m, 772 11-3-3, 772 11-3-4, 772 11-3-6, 772 11-3-8; 3321BA, 72 km ENE of Laingsburg, on dolerite, alt. 305-455 m, 768 12-2-2; (3321BD, Distr. Calitzdorp, Calitzdorp-Kruisrivier Maas-Geesteranus 6703 (L); 3322AC, Distr. Oudtshoorn, Cango Caves, Arnell 1449, 1451, LD); 3322BB, 58 km WNW of Willowmore, on Ecca sandstone, alt, 760-915 m, 772 14-2-4 (A specimen with a very unusual chemistry); 3322BC, 18 km N of De Rust, Meiringspoort, on Bokkeveld shale, alt. 640-730 m, 772 14-1-1, 772 14-1-3, 772 14-1-10, 772 14-1-12, 772 14-1-15, 772 14-1-18, 772 14-1-19; 3323AB, 14 km N of Willowmore, Perdepoort, on Witteberg quartzite, alt. 850-880 m, 772 14-3-1, 772 14-3-2, 772 14-3-3, 772 14-3-4, 772 14-3-5, 772 14-3-6, 772 14-3-8, 772 14-3-9; (3325CD, Distr. Uitenhage, Höeg, 6/7/29, TRH); 3420BB, small hill exposed to the sun, 7 miles W of Heidelberg, Dist. Swellendam, Cape Province, O.A. Höeg, 12/7/29, TRH.

Xanthoparmelia psoromifera (Kurok.) Hale

Plate 31D; Fig. 25. (p. 186).

Hale (1974) Phytologia, 28 (5): 488.

Parmelia psoromifera Kurokawa (1967) Bull. Natl. Sci. Mus. (Tokyo), 10 (3): 374; Pl 2, fig. 2

Holotypus: Jalisco, 25 km south of Guadalajara, Mexico; on rock. M. Wirth 22, (US).

Parmelia nigropsoromifera Nash (1974a) Bull. Torrey Bot.
Club, 101 (6): 320-321.
Holotypus: 8 km N of the east end of Lake Rooseveld
along Arizona Highway 288, on volcanic rock, desert
grassland community, 1100 m elevation, 19 April 1973,
Nash 7416 (ASU, isotypi COLO, DUKE, MIN, US, WIS)

Thallus foliose; moderately to tightly adnate; on rock; up to 12 cm across. Lobes elongate to very elongate; frequently evenly appressed, to sporadically unevenly appressed, and then the thallus with a squamulose appearance; discrete to contiguous; 1.5-7 mm broad; 150-350 µm thick. Obverse surface yellow-green; emaculate; dull or minutely felty to sometimes coarse pruinose at the lobe tips; epicortex heavily pored to rudimentary; not isidiate or sorediate. Obverse cortex 15-40 µm, the upper 10-20 µm obscured by usnic acid. Algal layer 20-80 µm. Medulla 80-240 µm. Reverse cortex 10-15 µm. Reverse surface pale brown to black; with rhizines scanty to moderately numerous, average sized to coarse.

Apothecia frequent; when present, sparse to common; substipitate; up to 6 mm across; shallowly cupped. Hymenium surface black, not pruinose. Hymenium 40-60 µm. Subhymenium 5-15 µm. Exciple 20-40 µm. Ascospores 8 per ascus, 6½-12 µm X 4½-6½ µm (10/1). Pycnia 100-200 µm in mean diameter. Pycnoconidia 6-8½ µm long.

Medulla white; K-; C-; KC-; P+ golden yellow.
Chemistry:- Usnic, psoromic and 2'-O-demethylpsoromic acids. Although the psoromic acid in this species was identical in TLC characteristics to that in *Rhizocarpon geographicum* (L) DC, it did not produce characteristic crystals in GE, which an extract of *R. geographicum* did.

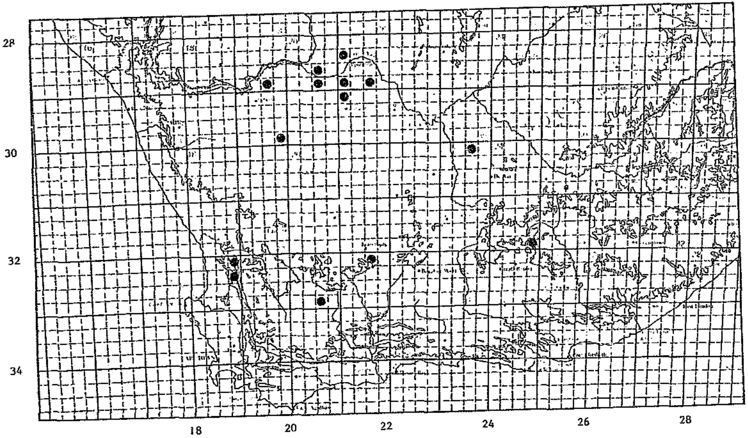


Fig. 25 Distribution of *Xanthoparmelia psoromifera*.

Outwardly this species resembles the *X. schenckiana* group, but is slightly less robust, among other minor but significant differences. Most specimens cited below are black below with a few which are pale brown below. Too few specimens were available to make any sound taxonomic judgements on the under surface colour. *X. psoromifera* although comparable to *X. schenckiana* and *X. colorata*, appears unrelated to these species and differs from them primarily in chemistry.

The species is widely distributed throughout the study area, but is common only in the Northern Karoo (1.4.1). It is also present in the drier parts of North America (Kurokawa, 1967; Nash, 1974a; Egan, 1975). Specimens examined: 2819DC, 38 km NE of Pofadder, on dolerite, alt. 920-1060 m, 768 9-2-1, 768 9-2-2 ("squamulose habit"); 2820DA, 8 km E of Kakamas, Bobbejaanskrans/Bavianskrans Pass, on schist (Kheis group), elev. 700-760 m, 768 8-8-1; 2820DC, near Kakamas on stone. P.A. v.d. Bijl 1146 (W); 2821AC, 20 km WNW of Upington, Seeppotkoppie, on Colston granite, alt. 870-890 m, 772 1-2-1 to 772 1-2-9; 2821CC, 10 km SSE of Keimoes, on granite, alt. 760-815 m, 768 8-6-1; 2821DC, 10 km E of Kleinbegin on Kaaien quartzite (Kheis group), alt. 945-975 m, 772 16-6-1, 772 16-6-2; 2919DD, 8 km NE of Graanaatboskolk, on dolerite, alt. 910-1060 m, 772 3-3-5, 772 3-3-6, 772 3-3-7; 2921AA. 24 km N of Kenhardt, N'Rougasberg, on quartzo-felspathic rock, alt. 850-880 m, 768 8-4-1; 3023BA, 22 km S of Strydenburg, on dolerite, alt. 1000-1200 m, 768 5-3-5; 3124DD, Lootsberg Pass half-way between Graaff-Reinet and Middleburg, on Beaufort mudstone, alt. 1800 m, 772 15-2-21; 3218BB, 11 km NE of Clanwilliam, Pakhuis Pass, on TMS, alt. 610-670 m, 772 8-3-1, 772 8-3-9; 3218BD, 26 km S of Clanwilliam, Olifants river valley, on TMS, alt. 400-600 m, 772 8-1-19; 3220DC, 34 km N of Matjiesfontein, Turck's Pass, alt. 1200-1235 m, on Ecca shale, 772 4-4-5; 3221BA, 16 km SSE of Fraserburg, Zaai Klipheuvels, on dolerite, alt. 1400-1430 m, 772 10-4-2, 772 10-4-8.

Xanthoparmelia ralla sp. nov.

Plate 35A; Fig. 26. (p. 189).

Thallus crustosus; in rupibus; usque ad 2½ cm diametro; areolatus sed peripherium versus lobatus. Lobi elongati vel perelongati, usque ad 2½ mm longi; contigui; 0.1-0.5 mm lati; semper minus quam 100 µm crassi. Areolae 0.1-0.5 mm lati. Pagina supera flavovirens; emaculata; hebetata; epicortice destituta vel rudimentali; isidiis sorediisque destituta. Medulla pertenuis. Pagina infera praeter ad apices loborum destituta.

Apothecia numerosa; immersa vel adnata, usque ad 0.7 mm diametris; plana vel convexa. Hymenium 40-60 µm altum. Subhymenium vadose conicum, usque ad 80 µm crassum. Excipulum 20-40 µm crassum. Ascosporae octonae, 6½-10½ µm X 4½-7 µm. Pycnia non visa.

Acidum usnicum in cortice superiore, et in strato algarum et medulla norlobaridonum continens.

Holotypus: South Africa, Cape Province, district Laingsburg, 3321AD, *Seven Weeks Poort, on Table Mountain sandstone*, alt. 915-945 m, 772 11-3-7. Isotypi: 772 11-3-3pp, 772 11-3-4pp, 772 11-3-6pp.

Thallus crustose; on rock; up to 2½ cm in diameter; areolate, but lobate towards the periphery. Lobes elongate to very elongate, up to 2½ mm long; contiguous; 0.1-0.5 mm wide, always less than 100 µm thick. Areoles 0.1-0.5 mm broad. Upper surface yellow-green; emaculate: dull; with the epicortex absent to rudimentary; non-isidiate and esorediate. Medulla very thin. Lower surface absent, except at the lobe ends.

Apothecia abundant, immersed to adnate; up to 0.7 mm in diameter; plane to convex. Hymenium 40-60 µm high. Subhymenium shallowly conical, up to 80 µm thick. Exciple 20-40 µm thick. Ascospores eight, 6½-10½ µm X 4½- 7 µm. Pycnia not seen.

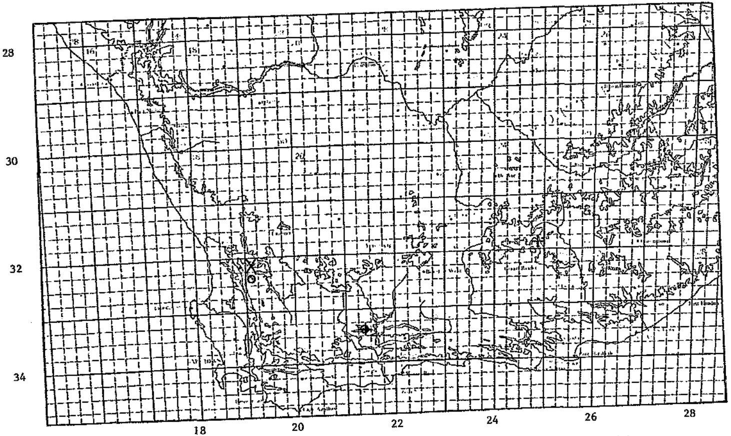


Fig. 26 Distribution of *Xanthoparmelia ralla* (O), *X. squamatica* (X) and *X. heterodoxa* (+).

Contains usnic acid in the upper cortex, and norlobaridone in the algal layer and medulla.

The placement of this lichen in *Xanthoparmelia* is somewhat tentative as the apothecial structure differs from the norm. The subhymenium is thick and cone shaped, and the exciple is thin and poorly developed, compared to the equivalent structures in a typical *Xanthoparmelia* apothecium. An alternative treatment would be to place the species in a genus in the Lecanoraceae Fée. In southern Africa, both *Neofuscelia* and *Xanthoparmelia* extend into the domain of the Lecanoraceae as presently understood. However, the habit of this species is very reminiscent of a *Xanthoparmelia*.

X. ralla is most similar to *X. heterodoxa* in morphology, but the latter differs in containing evernic acid. *Neofuscelia applicata* (Stiz.) Essl. has the same medullary chemistry but contains no acetone extractible substances in the upper cortex, but rather a brown amorphous pigment (Esslinger, 1973).

Specimens examined: 3219AC, 12 km WNW of Algeria, on TMS, alt. 760-915 m, 768 11-1-5; 3321AD, Seven Weeks Poort near Ladismith, on TMS, alt. 915-945 m, 772 11-3-3pp, 772 11-3-4pp, 772 11-3-6pp, 772 11-3-7.

Xanthoparmelia scabrosa (Tayl.) Hale

Plate 24C; Fig. 77. (p.191).

Hale (1974) Phytologia, 28 (5): 488.

Parmelia scabrosa Taylor (1847) London Journ. Bot., 6: 162.

Holotypus: Australia, Swan River, Mr. James Drummond, 1843. (FH! Isotypi in BM!) See Kurokawa (1969) J. Hattori Bot. Lab., (32): 211-212, for synonomy.

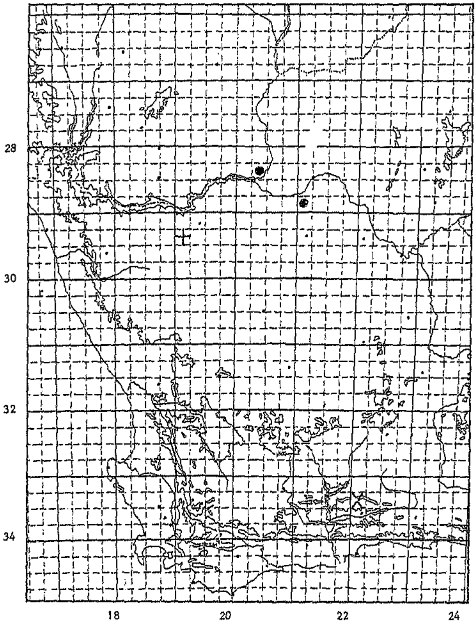


Fig. 27 Localities at which *Xanthoparmelia conspersa* (X), *X. scabrosa* (●) and *X. subramigera* (+) were found.

Thallus foliose; tightly adnate; on rock. Lobes elongate; evenly appressed, contiguous, ½-3 mm broad, 80-250 µm thick. Upper surface green; emaculate; dull to glossy at some lobe tips; isidiate, with isidia cylindrical to clavate, 0.03-0.1 mm thick by up to 0.4 mm long; esorediate. Lower surface pale brown; moderately rhizinate.

Apothecia not seen.

Pycnia 100-150 µm in mean diameter. Pycnoconidia not seen.

Medulla white; K-; KC+ rose; C-; P-.

Chemistry:- Usnic acid and norlobaridone.

This uncommon species was collected only twice in the Northern Karoo (1.4.1), but is probably widely distributed in the interior of South West Africa. It has been reported for Australia and Japan (Kurokawa, 1969), New Zealand (Green and Snelgar, 1977; Galloway, 1979), and South Africa (Hale, 1971). *X. scabosa* cannot be mistaken for any other Karoo species, because of the isidia and the chemistry. No non-isidiate counterpart is known in the study area. The only other species containing norlobaridone is the crustose *X.* [illegible].

Specimens examined: 2017AC, Südwesafrika, Wasserberg bei Windhoek, auf Schiefer, Leg. Fincke. W (1911) 3787 (Holotype of *Lecanora placodina*. Zahlbr. = *Lecanora diminuta* (Müll. Arg.) Stiz.); 28[illegible]AD, 86 km WNW of Upington, on granitic rock, alt. 760-920 m, 772 1-3-1; 2821CC, 10 km SSE of Keimoes, on granite, alt. 760-920 m, 768 8-6-3.

Xanthoparmelia schenckiana (Müll. Arg.) Hale

Plate 31A, and B; Fig. 28. (p. 195).

Hale (1974) Phytologia, 28 (5): 489.

Parmelia schenckiana Müller Argoviensis (1888) Flora, 71: 529.
Holotypus: Obib, in der Nähe des Oranje River, Gross
Namaland, Afr. occid. A. Schenck n. 542.
com. Dr. Schinze 1888 (G!)

Thallus foliose, tightly but sometimes moderately adnate; on rock; up to 12 cm across. Lobes elongate to very elongate; evenly appressed; discrete to contiguous; 1½-7 mm, but prominently 4-6 mm broad; 150-400 µm thick. Upper surface yellow-green; emaculate; minutely felty to coarse pruinose (plate 31B); with the epicortex rudimentary; neither isidiate nor sorediate. Upper cortex 20-60 µm. Algal layer 20-80 µm. Medulla 80-300 µm. Lower cortex 10-20 µm. Reverse surface black; sparsely to moderately rhizinate.

Apothecia very frequent; when present, sparse to abundant; substipitate; up to 1 cm across; suburceolate to shallowly cupped. Hymenium surface black, commonly fine white pruinose as well. Hymenium 50-70 µm. Subhymenium 10-20 µm. Exciple 30-70 µm. Ascospores 8 per ascus, 7½-11½ µm X 4½-7 µm (60/2). Pycnia 100-200 µm in mean diameter. Pycnoconidia commonly 8-10 µm, but occasionally up to 12 µm long.

Medulla white, often dirty orange to rusty brown towards the lower cortex of the interior lobes; K-; KC+ pale wine rose, fading; C-; P+ orange to orange-red, with the pigmented portions K+ purple. Chemistry:- Usnic and protocetraric acids with or without the two pigments sch-1 and sch-2.

X. schenckiana is common in, and is a distinctive species of the Karoo, but is uncommon in the Northern Karoo (1.4.1). It is closely related to *X. colorata*, which differs in containing salazinc acid, and in having a more restricted distribution on the western and southern margins. Both are surprisingly constant in growth habit.

In the south east of the study area, this species may resemble *X. subconspersa*, which may also contain protocetraric acid as the sole medullary constituent. However, *X. subconspersa* is moderately to loosely adnate, *with a pale brown reverse surface, at* least in the centre. The obverse surface texture and apothecial habit also differ. *X. psoromifera* and *X. schenckiana* may look alike, but the former is distinct from the latter in chemistry, containing psoromic acid (P+ yellow). The South American *X. flavobrunnea* (Müll. Arg.) Hale, is reminiscent of *X. schenckiana* and *X. colorata*, but has a peculiar lower surface, being black with an ash-grey wash (pruinose ?). The uppersurface is minutely felty throughout, and is grey-green (glaucous) in colour due to atranorin *and usnic acid in the upper* cortex.

Specimens examined: 2816BA, Obib, in der Nähe des Oranje River, A. Schenck n. 542, com. Dr. Schinz, 1888. (G); 2821CC, 29 km SSE of Keimoes, Piet Rooisberg, on pink granite, alt. 940-1040 m, 768 8-5-1; 2917BD, 29 km N of Springbok, Vrieskloofhoogte/Ratelpoort, on white gneiss, alt. 880-940 m, 772 2-4-23; 2919AC, 40 km SW of Pofadder, Namiesberg, on quartzo-felspathic rock, alt. 960-1040 m, 772 3-2-1, 772 3-2-2; 3017BD, 19 km S Kamieskroon, Karkams, on granitic rock, alt. 760-790 m, 772 *9-2-19 (fragment); 3018CA, 20 km SSE of* Garies, on gneiss, alt. 360-380 m, 772 9-1-17; 3018DA, 10 km S of Kliprand, on granitic rock, alt. 780-800 m, 768 9-7-1, 768 9-7-2; 3019CD, 6 km S of Louriesfontein, Kubiskouberg, on dolerite, alt. 880-900 m, 772 3-4-2pp, 772 3-4-5, 772 3-4-24; 3021DD, 15 km W of Carnarvon, on Ecca siltstone, 1220-1370 m elev., 768 7-1-1, 768 7-1-2, 768 7-1-3; 3022CC, 24 km NNW of Carnarvon, on dolerite, alt. 1130-1170 m, 772 16-2-3, 772 16-2-5; 3022CD, 18 km NE of Carnarvon, on dolerite, alt. 1280-1310 m, 768 6-5-3; 3120AD, 53 km W of Williston, on dolerite, alt. *± 1070 m, 772* 10-1-3, 772 10-1-4, 772 10-1-5; 3120BB, 24 km NW of Williston, on dolerite, alt. 1070-1220 m, 768 7-5-3;

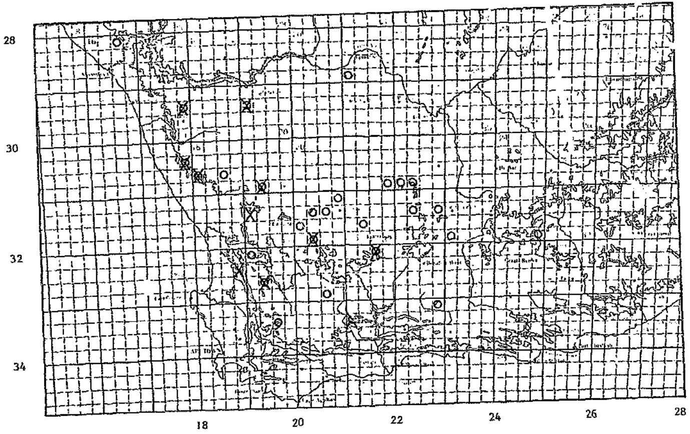


Fig. 28 Distribution of *Xanthoparmelia colorata* (X) and *X. schenckiana* (O).

3120BC, 34 km W of Williston, Jan Swartsberge, on dolerite, alt. 1170-1200 m, 772 10-2-1, 772 10-2-6, 772 10-2-7; 3120CA, 48 km NW of Middelpos, on dolerite, alt. 915-1220 m, 772 4-1-1pp, 772 4-1-5pp, 772 4-1-9; 3120CD, 12 km ESE of Middelpos, on Beaufort mudstone, alt. 1250-1280 m, 772 4-2-8, 772 4-2-16, 772 4-2-23pp; 3121CB, 27 km NW of Fraserburg, on Beaufort mudstone, alt. 1250-1265 m, 772 10-3-2, 772 10-3-3, 772 10-3-4pp, 772 10-3-5pp, 772 10-3-6; 3122AD, 3 km NNW of Loxton, on Beaufort mudstone, alt. 1370-1525 m, 772 15-4-5, 772 15-4-10, 772 15-4-17; 3122BD, 27 km W of Victoria West, on dolerite, alt. 1350-1400 m, 772 15-3-5, 772 15-3-16, 772 15-3-20; 3123CC, Three Sisters, on dolerite, alt. 1140-1240 m, 768 12-4-1; 3124DD, Lootsberg Pass half-way between Graaff-Reinet and Middleburg, on Beaufort mudstone, alt. 1800 m, 772 15-2-1, 772 15-2-3pp, 772 15-2-7, 772 15-2-8, 772 15-2-19; 3219AA, 34 km NE of Clanwilliam, Klipfonteinrant, on TMS, alt. 300-460 m, 768 10-3-1; 3219CB, 51 km SSE of Algeria, Grootrivierhoogte, on TMS, alt. 815-920 m, 768 11-2-3, 768 11-2-6pp, 768 11-2-10, 768 11-2-12, 768 11-2-16pp; 3220DC, 60 km SW of Sutherland, Tanqua river valley, on dolerite, alt. 820-850 m, 772 4-3-1, 772 4-3-6pp, 772 4-3-7; 3220DC, 34 km N of Matjiesfontein, Turck's Pass on Ecca shale, alt. 1200-1235 m, 772 4-4-4, 772 4-4-6pp, 772 4-4-15; 3221BA, 16 km SSE of Fraserburg, Zaai Klipheuvels, on dolerite, alt. 1400-1430 m, 772 10-4-2pp; 3319BC, 46 km ENE of Ceres, on Bokkeveld shale, alt. 920 m, 768 11-3-14, 768 11-3-16, 768 11-3-17; 3321AC, 38 km SE of Laingsburg, on Bokkeveld shale, alt. 610-760 m, 772 11-2-5pp; 3322BB, 58 km WNW of Willowmore, on Ecca shale, alt. 760-915 m, 772 14-2-1, 772 14-2-2, 772 14-2-3, 772 14-2-4pp.

Xanthoparmelia squamatica sp. nov.

Plate 36B; Fig. 26. (p. 189).

Thallus crustosus; in rupibus; usque ad 5 cm *diametro*; areolatus, sed peripheriam versus lobatus. Lobi elongati, usque ad 2 mm longitudinibus; contigui; 0.2-0.7 mm lati; 100-300 µm crassi. Areoli 0.2-1.3 mm diametris. Pagina superior flavovirens; emaculata; minute coactata, vel hebetata; sorediis isidiisque destituta. Cortex superior 10-20 µm crassus. Stratum algarum 30-80 µm crassum. Medulla 60-200 µm crassa. Cortex inferior 10-15 µm crassus. Pagina inferior praeter ad apices loborum destituta; pallide fusca; rhizinis destituta.

Apothecia non visa. Pycnia parva, circa 50 µm diametris. Pycnoconidia 7-11 µm longa.

Medulla alba; K+ leviter lutea; KC-; C-; P-; valde cyano-nivea in UV^{350} fluorescens. Acidum usnicum in cortice superiore et acidum squamaticum in medulla continens.

Holotypus: South Africa, Cape Province, district Clanwilliam, 3219AA, 20 km ENE of Clanwilliam, top of Pakhuis Pass, on Table Mountain sandstone, alt. 880-915 m, 772 8-2-1 (Isotypus: 772 8-2-6).

Thallus crustose; on rock; up to 5 cm in diameter; areolate, but lobate towards the periphery. Lobes elongate, up to 2 mm in length; contiguous; 0.2-0.7 mm broad; 100-300 µm thick. Areoles 0.2-1.3 mm in diameter. Upper surface yellow-green; emaculate; minutely felty, or dull; esorediate and non-isidiate. Upper cortex 10-20 µm thick. Algal layer 30-80 µm thick. Medulla 60-200 µm thick. Lower cortex 10-15 µm thick. Lower surface only under the lobe tips; pale grey-brown; without rhizines.

Apothecia not seen. Pycnia small, about 50 µm in diameter. Pycnoconidia 7-11 µm long.

Medulla white; K+ light yellow; KC–; C–; P–; strongly blue-white fluorescent in UV^{350}. Usnic acid in the upper cortex and squamatic acid in the medulla.

This species resembles *X. adhaerens* in morphology, but is easily distinguished from the latter and other crustose species by the strong blue-white fluorescence of the medulla in longwave UV. One strain of *X. hypomelaena* contains squamatic acid as an accessory substance, but this is a foliose species of the *X. hypoleia* group, and is unrelated to *X. squamatica*.

Xanthoparmelia subconspersa (Nyl.) Hale

Plate 21; 22C, and D; 23A, and B; Fig. 29. (p. 203).

Hale (1974) Phytologia, 28 (5): 489.

Parmelia subconspersa Nylander (1869) Flora, 52: 293.

Lectotypus: Ins. Borbonia. (H-NYL 34702b!).

Parmelia mutabilis Taylor (1847) Lond. Journ. Bot., 6: 171-172. (non Fries)

Holotypus: 5 Rocks, Uitenhage, Zeyher (FH!)

Parmelia austroafricana Stirton (1877) Trans. Glas. Soc. Field Nat., 5: 212-213.

Holotypus: South Africa, Somerset East, Klyn Visrivier, Prof. P. MacOwan, No. (Crypti) 507, 1874. (GLAM!).

Parmelia pheophana Stirton (1877) Trans. Glas. Soc. Field Nat., 5: 214-215.

Holotypus: South Africa, Somerset East, Prof. P. MacOwan (GLAM!)

Parmelia pheophana var *stenotera* Stirton (1877) Trans. Glas. Soc. Field Nat., 5: 215.

Holotypus: Ad rupes riparum, Fluvum Klyn Visch Rivier juxta pagum Somerset East, (CBS) Legit. MacOwan LXXIV No. (Crypti) 508 (GLAM!)

Parmelia conspersa var *austroafricana* (Stirt.) Stizenberger (1890) Ber. Thatigk. St. Gall. naturw. Ges., 1888-89: 152.

Parmelia conspersa var *subconspersa* (Nyl.) B. Stein apud Meyer (1890) Ostafrikanischen Gletscherfahrten p. 360.

Omphalodium mutabile (Tayl.) Minks (1900) Mém. Herb. Boiss., (21): 86-87.

Imbricaria subconspersa (Nyl.) Jatta (1902) Nuovo G. Bot. Ital., (nuova ser.), 9: 470.

Parmelia terricola J. Steiner et Zahlbrückner apud Zahlbrückner (1926) Bot. Jahrb. Syst. Pflanzengesch. Pflanzengeogr., 60: 510-511.

Holotypus: Kapland, Hügel bei Port Elizabeth, auf Erde, J. Brunnthaler, 20.11.1909 (W (1931) 8351!)

Parmelia protomatrae Gyelnik (1931) Feddes Repert. Specierum Nov. Regni Veg., 29: 395.

Holotypus: Hungaria; Propa Budapest, in monte Vadállókövek, ad rup. vulcanic (Krog, 1978).

Parmelia conspersa f. *terricola* (J. Stein. et Zahlbr.) Gyelnik (1936). Ann. Mus. Natn. Hungarici, 30: 128-129.

Parmelia ceresina Vainio ex Lynge (1937) Rev. Bryol. Lichenol., 10: 87-89.

Holotypus: Africa, Cape Province, Ceres. T.B. Leslie, 1924. (Hb Vain. 34574) TUR-VAIN 33498!

Parmelia digitatula var *saxicola* Gyelnik (1938) Sydowia Ann. Mycol., 36 (4): 276.

Holotypus: South Africa, Wolseley, on the ground. Leg. A.E. v.d. Byl (P.A. v.d. Bijl 1144) W!

Parmelia austroafricana f. *saxicola* (Gyel.) Gyelnik (1938) Ann. Mus. Natn. Hungarici (Pars Bot.), 31: 22.

Parmelia conspersa f. *stenotera* (Stirt.) Gyelnik (1938) Ann. Mus. Natn. Hungarici, (Pars Bot.), 31: 36.

Parmelia taylori Dodge (1959) Ann. Mo. Bot. Gard., 46: 60-61 (as nom. nov. for *P. mutabilis* Tayl.)

Parmelia stenotera (Stirt.) Dodge (1959) Ann. Mo. Bot. Gard., 46: 73.

Parmelia wrightii Dodge (1959) Ann. Mo. Bot. Gard., 46: 128.

Holotypus: Rocks. C.P.S. U.S.A. Pac. Expl. Exp. C. Wright. In hb. Tuckerman, sub *P. conspersa* (FH!)

Xanthoparmelia austroafricana (Stirt.) Hale (1974) Phytologia, 28 (5): 486.

Xanthoparmelia protomatrae (Gyel.) Hale (1974) Phytologia, 28 (5): 488.

Thallus foliose; moderately to loosely, but sometimes rather tightly adnate; on rock; up to 15 cm across; very variable in appearance; with a moderate habit range. Lobes elongate, very elongate to sublinear; uniformly appressed to ascending; contiguous to highly imbricate; 0.3-10 mm broad; 80-700 µm thick. Upper surface yellow-green to green; emaculate to faintly maculate; dull to glossy; pored epicorticate; non-isidiate and esorediate. Upper cortex 10-30 µm. Algal layer 20-60 µm. Medulla 40-600 µm. Under cortex 5-15 µm, but becoming thicker and less well differentiated in the interior (20-30 µm). Lower surface pale brown, but becoming chestnut brown to black on the terminal lobes, to sometimes extensively blackened in a variously broad outer zone; with rhizines abundant to absent, small to coarse, passing into holdfasts.

Apothecia common; when present, sparse to abundant; substipitate; up to 2 cm across; shallowly cupped. Hymenium 40-60 µm. Subhymenium 5-20 µm. Exciple 20-80 µm. Ascospores [6-] 7-10½ [-14] µm X [3½] -4½-6½ [-7] µm (342/11).

Pycnia 100-200 µm in average diameter. Pycnoconidia 5-8 µm long.

Medulla white, but becoming yellow-orange on the lower cortex of some specimens; containing fumarprotocetraric, protocetraric and succinprotocetraric acids, less frequently with small amounts of physodalic and virensic acids, in varying proportions and combinations; (a) of specimens containing protocetraric acid only; K-; KC+ pale rose, fading; C-; P+ orange to red; (b) of the remaining specimens; K- at first, then gradually becoming a dingy orange (rarely a pure orange colour) to dingy-red over a period of a few minutes; KC no change, or bleaching the initial K reaction somewhat, or darkening slightly then fading, when protocetraric acid is additionally present; C-; P+ red to blood-red. In addition, some specimens with the yellow orange pigment, skyrin, are K+ violet on the lower cortex, and all specimens contain usnic acid in the upper cortex.

This is a very widespread species occurring throughout at least the eastern part of Africa. It is common in the southern and marginal areas of the Karoo, and is very common in the Eastern Cape, Transkei and the Drakensberg. The major variation in this species occurs as lobe width, lobe thickness, and angle of lobe elevation, with adnation fairly constant. The amount of blackening on the reverse surface is also variable, as is the thallus texture, brittle to leathery. Broad lobed specimens may resemble some eciliate, imperforate *Parmotrema* species, but the ascospores are smaller, commonly 8-10 µm X 5-6.5 µm and pale undersurfaces are infrequent in this genus. (Hale, 1965; Winnem, 1975).

Succinoprotocetraric acid is most frequent, occurring with or without proto- or fumarprotocetraric acid or both and sometimes with traces of physodalic and/or virensic acids. Protocetraric acid has been found alone, or with fumar- and/or succinoprotocetraric acid. Fumarprotocetraric acid was infrequent in the present collection, occurring with succinoprotocetraric acid and sporadically with protocetraric acid.

X. subconspersa and *X. chalybaeizans* may look alike on occasion, but the latter is immediately K+ yellow or yellow-orange and contains salazinic acid and the "chalybaeizans unknown". *X. chalybaeizans* has different morphological tendencies and is more variable than this species. The holotype specimen of *X. hyporhytida* is reminiscent of some ascending lobed forms of *X. subconspersa* found on the western and southern margins.

Specimens examined: 2821CC, 29 km SSE of Keimoes, Piet Rooisberg, on soil at the base of a granite outcrop with *Dermatocarpon* sp., alt. 940-1040 m, 768 8-5-3pp, 768 8-5-8pp; 2917BD, 29 km N of Springbok, Vrieskloofhoogte, on white gneiss, alt. 880-940 m, 772 2-4-19; 3017BD, 19 km S of Kamieskroon, Karkams/Garagams, on granitic rock, alt. 760-790 m, 772 9-2-8, 772 9-2-14, 772 9-2-16; 3018CA, 20 km SSE of Garies, on gneiss, alt. 360-380m, 772 9-1-13, 772 9-1-20, 772 9-1-33; 3018DA, 10 km S of Kliprand, on granite, alt. 780-800 m, 768 9-7-3; 3019CD, 6 km S of Louriesfontein, Kubiskouberge, on dolerite, alt. 880-900 m, 772 3-4-7, 772 3-4-12, 772 3-4-18, 772 3-4-21, 772 3-4-22; 3023BA, 22 km S of Strydenburg, on dolerite, alt. 1100-1130 m, 768 5-3-4; 3119AC, 42 km NE of Vanrhynsdorp, halfway up Vanrhyns Pass, on TMS, alt. 460-610 m, 768 10-1-18; 3119AC, 45 km NE of Vanrhynsdorp, top of Vanrhyns

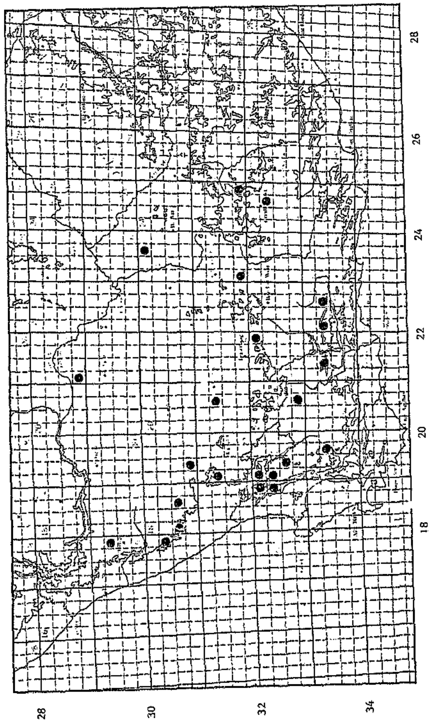


Fig. 29 Distribution of *Xanthoparmelia subconspersa* in the Karoo.

Pass, on TMS, alt. 800 m, 768 10-2-2, 768 10-2-23pp, 772 9-3-10; 3120BC, 34 km W of Williston, Jan Swartsberge, on soil under a rock, 1170-1200 m elev., 772 10-2-10; 3123CC, Three Sisters, on dolerite, alt. 1140-1240 m, 768 12-4-3, 768 12-4-17; 3124DD, Lootsberg Pass, halfway between Graaff-Reinet and Middleburg, on Beaufort mudstone, 772 15-2-9, 772 15-2-12, 772 15-2-14, 772 15-2-18, 772 15-2-27; 3218BB, 11 km NE of Clanwilliam, Pakhuis Pass, on TMS, alt. 610-670 m, 772 8-3-2pp, 772 8-3-4pp, 772 8-3-8, 772 8-3-13, 772 8-3-16, 772 8-3-18, 772 8-3-20; 3218BD, 26 km S of Clanwilliam, Olifants river valley, on TMS, alt. 400-600 m, 772 8-1-2, 772 8-1-7, 772 8-1-8pp, 772 8-1-11; 3219AA, 34 km NE of Clanwilliam, Klipfonteinrant, alt. 300-460 m, 768 10-3-4, (on *Omphalodium hottentottum* (Ach.) Flot.), 768 10-3-9 (on soil), 768 10-3-10 (on TMS), 768 10-3-11 (on TMS); 3219AA, top of Pakhuis Pass, on TMS, alt. 880-915 m, 772 8-2-10, 772 8-2-16, 772 8-2-17; 3219AC, 12 km WNW of Algeria, Rondegat river valley, on TMS, alt. 760-915 m, 768 11-1-1; 3219CB, 50 km SSE of Algeria, Grootrivierhoogte, on TM quartzite, alt. 850-915 m, 768 11-2-4pp, 768 11-2-5, 766 11-2-6, 768 11-2-8pp, 768 11-2-9, 768 11-2-16pp; 3220DC, 60 km SW of Sutherland, Tanqua river valley, on dolerite, alt. 820-850 m, 772 4-3-3; 3220DC, 34 km N of Matjiesfontein, Turck's Pass, on Ecca shale, alt. 1200-1235 m, 772 4-4-2pp; 3221BA, 16 km SSE of Fraserburg, Zaai Klipheuvels, on dolerite, alt. 1400-1430 m, 772 10-4-13 (unusually thick lobes); 3221BA, 37 km SSE of Fraserburg, Teekloof, on Beaufort mudstone, alt. 1160-1220 m, 772 10-5-8, 772 10-5-9, 772 10-5-12, 772 10-5-15; 3224BC, 6 km SW of Graaff-Reinet, Munnikspoort, on Beaufort mudstone, alt. 810-825 m, 772 15-1-9; 3319BC, 46km ENE of Ceres, on Bokkeveld shale, alt. ± 920 m, 768 11-3-3 (on soil), 768 11-3-9, 768 11- -18; 3321AD, Seven Weeks Poort near Ladismith, on TMS, alt. 915-94 m, 772 11-3-11, 772 11-3-14, 772 11-3-17, 772 11-3-22, 772 11-3-23, 772 11-3-35, 772 11-3-36, 772 11-3-42;

3322AC, 18 km S of Prince Albert, top of Swartberg Pass, on TMS, alt. 1700 m, 772 11-1-8pp, 772 11-1-11; 3322BC, 18 km N of De Rust, Meiringspoort, on Bokkeveld shale, 640-730 m elev., 772 14-1-20.

Xanthoparmelia subdecipiens (Vain. ex Lynge) Hale
Plate 27C, and D; Fig. 30. (p. 207).
Hale (1974d) Phytologia, 28 (5): 489.

Parmelia subdecipiens Vainio ex Lynge (1937) Rev. Bryol.
Lichenol., 10: 89-90.
Holotypus: Cape Province, Klapmuts, saxicole. P.A. v.d.
Bijl (Hb. Vain. 34577, T[illegible] VAIN!)
Parmelia brunnthaleri f. irregularis Gyelnik (1938) Sydowia
Ann. Mycol., 36 (4): 270.
Holotypus: South Africa, district Calvinia, Rooidan
Leg. P.A. v.d. Bijl, 1122 (W (1935)-!)
Parmelia atroventralis Hale (1971) Bot. Not., 124: 346, Fig. 1B.
Holotypus: Basutoland, Div. Qachas Nek, Black Mt. Leg.
L. Kofler, 6-2-1963 (LD!)
Xanthoparmelia atroventralis (Hale) Hale (1974) Phytologia
28 (5): 486.
Parmelia irregularis (Gyel.) Kurokawa apud Kurokawa et Filson
(1975) Bull. Natl. Sci. Mus. Ser. B (Bot.) 1 (1): 41.

Thallus foliose; loosely to tightly adnate; on rock, occasionally on soil and debris; up to 12 cm across. Lobes elongate to very elongate; contiguous to imbricate; ½-4 mm broad; 100-250 µm thick. Upper surface green or sometimes yellow-green; emaculate; dull to glossy; pored epicorticate; neither isidiate nor sorediate. Upper cortex 15-20 µm. Algal layer 20-60 µm. Medulla 50-180 µm. Lower cortex 5-15 µm. Lower surface pale brown to black; with rhizines sparse to moderately abundant.

Apothecia frequent; when present, sparse to plentiful; *substipitate; up to 8 mm across; shallowly cupped.* Hymenium 40-60 μm. Subhymenium 5-15 μm. Excipule 20-50 μm. Ascospores 8 per ascus, 7½-12 μm X 4½-7 μm (143/4). [illegible] 300 μm in mean diameter. Pycnoconidia 3-7 μm long.

Medulla white; K-; [illegible] -; P-.

Chemistry:- Usnic acid in the obverse cortex, subd-1 and many or all of the other unidentified aliphatic substances in the medulla.

This species is widespread but sporadic in the Karoo, but is more frequent on the southern margin. The species appears to be conservative in habit variation, but does tend to develop narrower lobes at moist localities. Nevertheless, the under surface colour varies from pale brown to black. This species is distinctive in its chemistry, and does not resemble any other species closely. The tentative isidiate counterpart *X. globulifera*, is similar in appearance, but is isidiate, is always pale brown below, and has a consistently different aliphatic acid chemistry.

Specimens examined (Specimens with pale undersurfaces are indicated with a (P), those with black undersurfaces with a (B), and those undecidedly dark brown to black with a (P/B): 2919BC, 32 km SSE of Pofadder, on quartz, alt. 1040-1050 m, 768 9-4-2(P); 2921AC, district Kenhardt, Rooidam near Kenhardt, P.A. v.d. Bijl 1122, W (1935)-(P); 2929CA, Black Mountains, distr. Qachas Nek, Lesotho. Kofler 6-2-1963, LD (B); 3028BA, Qachas Nek near Matatiele, on Clarens (Cave) sandstone, 765 29-1(P); 3120BB, 24 km NW of Williston, on dolerite, alt. 1070-1220 m, 768 7-5-4 (P/B); 3123CC, Three Sisters, on dolerite, 1140-1240 m elev., 768 12-4-2 (B); 3124DD, Lootsberg Pass, halfway between Middleburg and Graaff-Reinet, on Beaufort mudstone, alt. 1800 m, 772 15-2-10 (B);

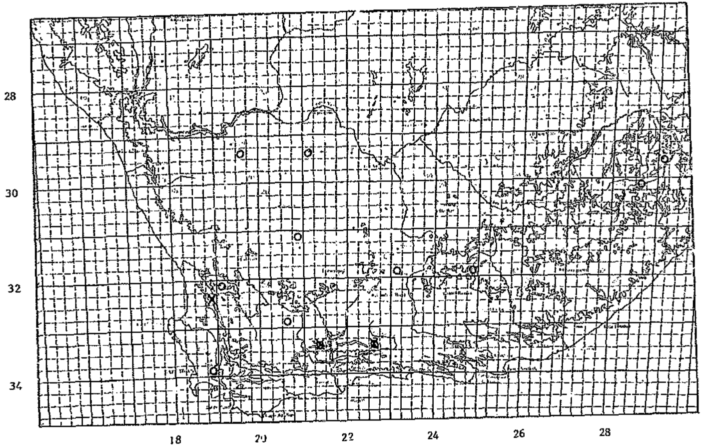


Fig. 30 Distribution of *Xanthoparmelia globulifera* (X) and *X. subdecipiens* (O).

3219AA, 34 km NE of Clanwilliam, Klipfonteinrant, on TMS, alt. 300-450 m, 768 10-3-5 (P); 3220DC, 60 km SW of Sutherland, on dolerite, alt. 820-850 m, 772 4-3-6pp (P); 3318DD, Klapmuts, P.A. v.d. Bijl (Hb. Vain. 34577, TUR-VAIN) (P); 3321AD, Seven Weeks Poort near Ladismith, on TMS, alt. 915-945 m, 772 11-3-1 (P), 772 11-3-20 (P); 3322BC, 18 km N of De Rust, Meiringspoort, on Bokkeveld shale, alt. 640-730 m, 772 14-1-2 (P), 772 14-1-16 (B), 772 14-1-21 (B).

Xanthoparmelia subramigera (Gyel.) Hale

Plate 24D; Fig. 27. (p. 191).

Hale (1974) Phytologia, 28 (5): 489.

Parmelia subramigera Gyelnik (1931) Feddes Repert. Specierum Nov. Regni Veg., 29: 409.

For typification and synonomy see Hale (1964) Bryologist, 67: 471-472.

Thallus foliose; moderately to loosely adnate; on rock. Lobes elongate; imbricate; 1-4 mm broad. Obverse surface green; non-maculate; dull to glossy; coarse isidiate, isidia 0.1-0.3 mm thick and up to 2.5 mm high, with the very tips breaking off cleanly; esorediate. Reverse surface pale brown; moderately rhizinate.

Apothecial scarce; substipitate; up to 4 mm across; shallowly cupped. Pycnia not seen.

Medulla white; K- then slowly becoming dingy orange; C-; P+ red. Chemistry:- Usnic acid in the obverse cortex, succinprotocetraric acid, and traces of physodalic and virensic acids, in the medulla.

According to Hale (1964) this species is widespread in the tropics and subtropics. It was collected once in the Northern Karoo (in the Namiesberg) and is otherwise absent. It was also reported absent from the Sonoran Desert in Arizona, an area with a similar climate to the present study area. The non-isidiate counterpart could be considered to be *X. subconspersa*, but this species is plentiful in the Karoo.

Specimens examined: 2919AC, 40 km SW of Pofadder, Namiesberg, on quartzo-felspathic rock, alt. 960-1040 m, 772 3-2-10, 772 3-2-12.

Xanthoparmelia tasmanica (Hook. f. et Tayl.) Hale

Plate 24B; Fig. 31. (p. 211).

Hale (1974) Phytologia, 28 (5): 489.

Parmelia tasmanica Hooker et Taylor (1844) Lond. Journ. Bot., 3: 644-645.

Holotypus: Van Diemens Land, Gunn FH!

Parmelia incisa Taylor (1847) Lond. Journ. Bot., 6: 162 (non Fries (1825) Syst. Orb. Veg., p 284).

Holotypus: Swan River, Mr. James Drummond, 1843. (FH; Isotypi BM!).

Parmelia synestia Stirton (1877) Trans. Glas. Soc. Field Nat., 5: 214.

Holotypus: South Africa, Cave M^{n}, J.H. McLea. On Mossy Stones (No 413) (GLAM!)

Parmelia conspersa var *laxa* Müller-Argoviensis (1883) Flora, 66: 47-48.

Lectotypus: Upper Ovens River. Mrs. McCann, 1882 (G!)

Parmelia subconspersa var *incisa* (Tayl.) Stizenberger (1890) Ber. Thatigk. St. Gall. naturw. Gesell., 1888-89: 153.

Imbricaria conspersa var *laxa* (Müll. Arg.) Jatta (1902) Nuovo G. Bot. Ital. (Nuova ser.), 9: 470.

Parmelia conspersa var *incisa* (Tayl.) Zahlbrückner (1929)
Cat. Lich. Univ., 6: 132.
Parmelia laxa (Müll. Arg.) Gyelnik (1935) Ann. Mus. Natn.
Hungarici (Pars Bot.), 29: 26.
Parmelia conspersa var *synestia* (Stirt.) Gyelnik (1938)
Ann. Mus. Natn. Hungarici, (Pars Bot.), 31: 41.

Thallus foliose; moderately to loosely adnate; on rock, soil, plant debris and mosses; up to 10 cm across. Lobes elongate to very elongate; *discrete to imbricate;* 0.3 to 5 mm broad; 100-320 μm thick. Upper surface green to yellow-green; emaculate, but sometimes faintly maculate; dull to glossy; pored epicorticate; non-isidiate and esorediate. Upper cortex 15-30 μm. Algal layer 20-60 μm. Medulla 50-250 μm. Under cortex 10-15 μm. Under surface black; scantily to moderately rhizinate;

Apothecia frequent; when present *sparse to numerous; substipitate;* up to 1.5 cm across; shallowly cupped. Hymenium 40-60 μm. Subhymenium 10-20 μm. Exciple 40-80 μm. Ascospores 8 per ascus, 7½-12½ [-14] μm X 4-6½ *μm (61/3)*. Pycnia 100-200 μm in mean diameter. Pycnoconidia 5-8 μm long.

Medulla faint pink; K+ yellow then turning blood-red; C-; P+ orange.

Chemistry:- Usnic and salazinic acids with accessory norstictic acid. Skyrin is also sporadically present near *and on the lower cortex.*

X. tasmanica displays a relatively moderate range of foliose thallus habits. It is found at moister localities on the western margin *and in the* southern part of the Karoo, and is somewhat cosmopolitan. This species was found to be rare in the Sonoran desert in Arizona whereas the pale undersurface counterpart, *X. taractica* (Kremp.) Hale, was fairly common. In the Karoo *X. tasmanica* is common at moister sites and *X. taractica* is absent, all K+ red specimens with pale

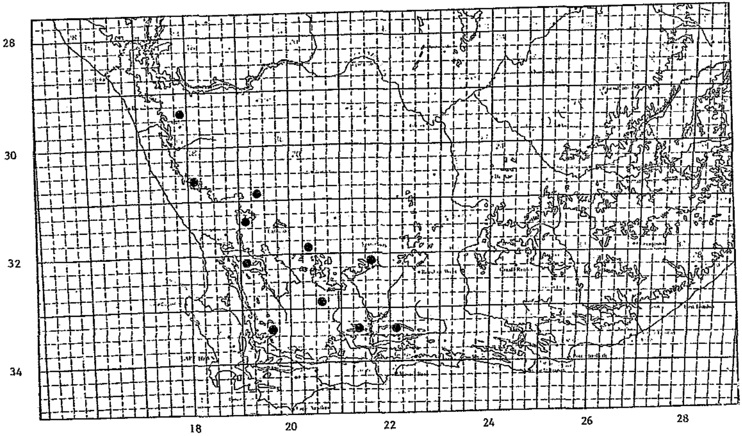


Fig. 31 Distribution of *Xanthoparmelia tasmanica.*

undersurfaces being *X. chalybaeizans*. The latter species has a different habit range to *X. tasmanica*, within the study area.

Specimens examined: 2917BD, 29 km N of Springbok, Vrieskloofhoogte/ Ratelpoort, on white gneiss, alt. 880-940 m, 772 2-4-13, 772 2-4-16; 3018CA, 20 km SSE of Garies, on gneiss, alt. 360-380 m, 772 9-1-34pp; 3019CD, 6 km S of Louriesfontein, Kubiskouberge, on dolerite, 880-900 m, 772 3-4-8, 772 3-4-11, 772 3-4-14, 772 3-4-15pp, 772 3-4-20, 772 3-4-26; 3119AC, 45 km NE of Vanrhynsdorp, top of Vanrhyns Pass, on TMS, alt. 800 m, 768 10-2-3, 768 10-2-15; 3120CD, 12 km ESE of Middelpos, on Beaufort mudstone, alt. 1250-1280 m, 772 4-2-1, 772 4-2-2, 772 4-2-4, 772 4-2-9, 772 4-2-12, 772 4-2-14A; 3219AA, 34 km NE of Clanwilliam, Klipfonteinrant, on TMS, alt. 300-450 m, 768 10-3-8, 768 10-3-9pp; 3219AA, 20 km ENE of Clanwilliam, top of Pakhuis Pass, on TMS, alt. 880-915 m, 772 8-2-8, 772 8-2-12, 772 8-2-15; 3220DC, 34 km N of Matjiesfontein, Turck's Pass, on Ecca shale, alt. 1200-1235, 772 4-4-1, 772 4-4-2, 772 4-4-3, 772 4-4-13; 3221BA, 16 km SSE of Fraserburg, Zaai Klipheuvels, on dolerite, alt. 1400-1430 m, 772 10-4-11, 772 10-4-12; 3319BC, 46 km ENE of Ceres, on Bokkeveld shale, alt. ± 920 m, 768 11-3-2, 768 11-3-3pp, 768 11-3-4; 3321AD, Seven Weeks Poort near Ladismith, on TMS, alt. 915-945 m, 772 11-3-18pp; 3322AC, 18 km S of Prince Albert, top of Swartberg Pass, on TMS, alt. 1700 m, 772 11-1-13.

Xanthoparmelia worcesteri (J. Stein. et Zahlbr.) Hale
Plate 26C; 30; 35C and D; Fig. 32. (p. 215).

Hale (1974) Phytologia, 28 (5): 490

Parmelia worcesteri J. Steiner et Zahlbrückner apud Zahlbrückner (1926) Bot. Jahrb. Syst. Pflanzengesch. Pflanzengeogr., 60: 511-512.

Holotypus: Kapland, Worcester, Hugel nördl. d. Ortes,
Schiefer, 250-300 m. J. Brunnthaler 7.11.1909
(*W* (1931) 8395!)

Parmelia lecanorica Hale (1971) Bot. Not., 124: 351, fig. 3B.
Holotypus: North-east of Clanwilliam, Pakhuis Pass,
Cape Province, South Africa, O. Almborn 4531, 12 Sept.
1953 (LD, Isotypus US)

Xanthoparmelia lecanorica (Hale) Hale (1974) Phytologia, 28
(5): 488.

Thallus foliose to sometimes subcrustose; tightly to very tightly [illegible]e; on rock; up to 10 cm across. Lobes elongate; [illegible] appressed; contiguous; 0.2-4 mm broad; 60-250 µm, but some central [illegible] areoles of subcrustose specimens up to 500 µm thick. Upper surface green to yellow-green; emaculate; dull becoming glossy at the lobe ends of all foliose specimens, but minutely felty becoming coarse-pruinose at the lobe ends of most subcrustose specimens; with the epicortex pored to rudimentary; *neither isidiate nor sorediate*. Upper cortex 15-30 µm. Algal layer 20-60 µm. Medulla 20-150 µm. Under cortex 10-20 µm. Under surface pale brown to black; with rhizines sparse to moderately plentiful, rudimentary on subcrustose specimens.

Apothecia very frequent; when present, sparse to abundant, adnate to substipitate; up to 5 mm across; flat to shallowly cupped. Hymenium 40-60 µm. Subhymenium 10-25 µm. Exciple 20-50 µm. Ascospores 8 per ascus, 6½-11 µm X 4-6½ µm.
Pycnia 50-150 µm in mean diameter. Pycnoconidia 5-8 µm long.

Medulla white; K-; C+ rose to red; KC+ rose to red; P-.
Chemistry:- Usnic and lecanoric acids.

This species displays a similar range of thallus conditions to *X. persperea*, but in this case the foliose habit is dominant, and specimens with black under surfaces are restricted to the western half of the area. The foliose and subcrustose varieties have been found together in the Central Karoo (1.4.2), and at the same site, in the Jan Swartsberg west of Williston, and at Three Sisters. Only careful on site studies using the C+ red reaction will reveal the effect of aspect and microaspect on thallus morphology in this species. *X. chalybaeizans* is also similar, but in this case the subcrustose habit is restricted to the western margin, there is a greater range of foliose variation, and the undersurface is always pale brown. No other species containing lecanoric acid are present in the area, but several species containig evernic acid (4-0-methyllecanoric acid) are present in the surroundings. These are *X. dysprosa, X. heterodoxa* (with lecanoric acid as a subsidiary compound) and an undescribed foliose species from the Namib desert. A similar taxon to *X. worcesteri* in North America is *X. arida* Egan et Derst., (whose isidiate counterpart is *X. joranadia* (Nash) Hale?).

Specimens examined: 2819DC, 38 km NE of Pofadder, on dolerite, alt. 920-1060 m, 768 9-2-4; 2917BD, 29 km N of Springbok, Vrieskloofhoogte/Ratelpoort, on white gneiss, alt. 880-940 m, 772 2-4-1; 2919AC, 40 km WSW of Pofadder, Namiesberg, on quartzo-felspathic rock, alt. 960-1040 m, 772 3-2-1, 772 3-2-3, 772 3-2-4, 772 3-2-5, 772 3-2-6, 772 3-2-8; 2921AA, 24 km N of Kenhardt, N'Rougasberg, on quartzo-felspathic rock, alt. 850-880 m, 768 8-4-1, 768 8-4-3, 768 8-4-5; 2923DD, 19 km NE of Strydenburg, Elands mountain, on dolerite, alt. 1190-1280 m, 768 5-1-5; 3017BD, 20 km S of Kamieskroon, Garagams/Karkams, on granitic rock, alt. 760-790 m, 772 9-2-18; 3018CA, 20 km SSE of Garies, alt. 360-380 m, 772 9-1-2, 772 9-1-6, 772 9-1-11, 772 9-1-12, 772 9-1-32; 3020DC, 62 km NW of Williston, on dolerite, alt 915-1150 m, 768 7-6-1, 768 7-6-2; 3021DD, 15 km W of Carnarvon, on Ecca siltstone, alt. 1220-1370 m, 768 7-1-2, 768 7-1-10;

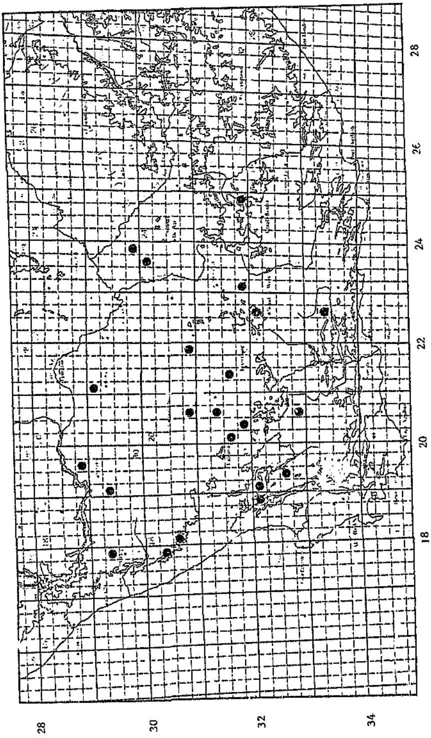


Fig. 32 Distribution of *Xanthoparmelia worcesteri*.

3023BA, 22 km S of Strydenburg, on dolerite, *alt. 1000-1200 m, 768 5-3-1;* 3120BC, 34 km W of Williston, Jan Swartsberg, on dolerite, alt. 1170-1200 m, 772 10-2-4, 772 10-2-5, 772 10-2-6; 3120CA, 48 km NW of Middelpos, on dolerite, alt. 915-1220 m, 772 4-1-12pp, 772 4-1-13; 3120CD, 12 km ESE of Middelpos, on Beaufort mudstone, alt. 1250-1280 m, 772 4-2-16pp, 772 4-2-23; 3121CB, 27 km NW of Fraserburg, Blydevooruitzicht, on Beaufort mudstone, alt. 1250-1265 m, 772 10-3-4; 3123CC, Three Sisters, *on dolerite, alt.* 1140-1240 m, 768 12-4-5, 768 12-4-6, 768 12-4-7, 768 12-4-8, 768 12-4-11, 768 12-4-12; 3124DD, Lootsberg Pass, midway between Graaff-Reinet and Middleburg, on Beaufort mudstone, alt. 1800 m, 772 15-2-2, 772 15-2-4; (3218BB, 14 km S of Clanwilliam, Almborn 4945, not seen; 3219AA, Pakhuis Pass, Almborn 12.9.1953, 4531, not seen); 3219CB, 51 km SSE of Algeria, Grootrivierhoogte, on quartzitic TMS, alt. 850-915 m, 768 11-2-4, 768 11-2-8, 768 11-2-12, 768 11-2-15; 3220DC, 34 km N of Matjiesfontein, Turck's Pass, on Ecca shale, alt. 1200-1235 m, 772 4-4-6, 772 4-4-12; 3222BA, 13 km N of Beaufort West, Molteno Pass, on dolerite, alt. 1400-1460 m, 768 12-3-3; 3319CB, Worcester, J. Brunnthaler, 7.11.1909, W 8395; 3322BC, 18 km N of De Rust, Meiringspoort, on Bokkeveld shale 640-730 m, *772 14-1-2, 772 14-1-5, 772 14-1-6,* 772 14-1-27.

DOUBTFUL AND EXCLUDED NAMES

Xanthoparmelia chlorea (Stiz.) Hale (1974) Phytologia 28 (5): 486.
Basionomen: *Parmelia chlorea* Stizenberger (1890) Ber. Thatigk.
St. Gall. naturw. Ges., 1888-89: 151.
Holotypus: Supra lapides in republica Oranje.Orpen
(ZT not seen).

This species is unique in its medullary chemistry, which causes distinctive colour reactions with K and P. The upper cortex contains atranorin only, and therefore should be placed in *Pseudoparmelia* Lynge sensu Hale.

Xanthoparmelia concolor (Spreng.) Hale (1974) Phytologia, 28
(5): 486.

Basionomen: *Parmelia concolor* Sprengel (1827) Systema
Vegetabilium, p. 328.

The typification of this name is considered to be beyond the scope of the present study, and was not used. Type material may be in S (Laundon, 1979). *X. concolor* is probably the correct name for the taxon presently referred to as *X. subconspersa*.

Parmelia interrupta Stizenberger (1890) Ber. Thatigk. St. Gall.
naturw. Ges., 1888-89: 154.
Holotypus: In montibus Warme *Bokkeveld prope* pagum Ceres
ad Promontorium Bonae Spei. MacOwan (ZT!)

Synonomen: *Squamaria interrupta* (Stiz.) Gyelnik (1935) Ann. Mus.
Natn. Hungarici, (Pars Bot.), 29: 35-36.

The clarification of this and the next names require more collections from the southern and southwestern Cape.

Parmelia perplexa Stizenberger (1890) Ber. Thatigk. St. Gall.
naturw. Ges., 1888-89: 154.
Holotypus: Saxicola prope pagum Ceres in montibus
Warme Bokkeveld - Africa australis MacOwan. (ZT!)

Parmelia subschenckiana Gyelnik (1938) Sydowia Ann. Mycol., 36 (4): 291-292.

Holotypus: South Africa, District Calvinia, Lokenburg, on stone. Leg. P.A. v.d. Bijl 1140 (W (1935)-!) Lacks usnic acid and should be placed in *Pseudoparmelia*.

A synonym of *P. chlorea* Stiz., fide Hale (annotation label).

Parmelia xanthotropa Stirton (1878) Scot Nat., 4: 202-203.

Holotypus: South Africa, Somerset East, Prof. P. MacOwan (BM!).

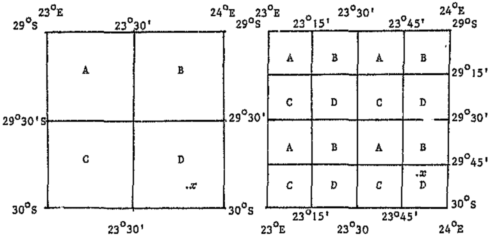
The holotype specimen is rather fragmentary, and is somewhat papillate, a condition that has not been found in any of the species.

5. APPENDIX

5.1 PARTICULARS OF COLLECTION SITES (TABLE 3)

Place names as in Leistner and Morris (1976). Rainfall data (in decimetres) from, and localities initially pinpointed on, 1:250,000 rainfall maps (Trigonometrical Survey Office (a)). Altitudes (in metres) from, and localities finally positioned on 1:50,000 maps, (Trigonometrical Survey Office (b)). Magisterial districts as in 1965-1966 (Trigonometrical Survey Office (a)).

The numbers of the quarter degree references refer to the degree status of the top left hand (NW) corner of the degree square in which it lies. The first letter refers to the half degree square and the second letter, the quarter degree square within the half degree square in which a particular locality lies:



In the above example, the locality *x* lies in the degree square 2923 (i.e. NW corner *is 29°S and 23°E), in the half degree square 2923D,* and in the quarter degree square 2923DD.

TABLE 3. PARTICULARS OF COLLECTION SITES

LOCALITY NUMBER	DESCRIPTION OF LOCALITY AND SITE	¼ $^\circ$REFERENCE $^\circ$S $^\circ$E	MIN ALT (m) MAX ALT (m) RAINFALL IN dm	CADASTRAL INFORMATION. MAGISTERIAL DISTRICT
768 5-1-n	19 km NE *of Strydenburg; Elands Berg*, △ 8; X. brunnthaleri from S side of dolerite boulders on north slope, others from S facing dolerite outcrop and large boulders.	2923 DD 29°51.3' 23°50.7'	1190 1280 2-3	*Elands Berg* No. 1, Ho Q.4-13 Hopetown
768 5-2-n	Strydenburg. Small hill W of the town, SSW slope with large dolerite boulders. N slope with no Xanthoparmeliae.	2923 DC 29°56.6' 23°40.25'	1080 1110 2-3	Strydenburg allotment area Roode Pan Ho.Q.10-18 Hopetown
768 5-3-n	22 km S of Strydenburg, series of rolling low hills with *dolerite boulders, on the right hand side of the road.*	3023 BA 30°08' 23°39.5'	1100 1130 2-3	- Britstown
768 5-4-n	26 km S of Strydenburg; Brak river bridge; gentle N facing Dwyka pavement, near the river. No lichens seen.	3023 BA 30°10.1' 23°38.2'	1070 1080 2-3	Barendsfontein Co Q.2-81 Britstown
768 5-5-n	16 km NNE of Britstown, large low flat topped koppie with dolerite boulders. SE to S slopes examined.	3023 BC 30°27.2' 23°33.2'	1160 1190 2-3	Rietfontein Ric Q.1-8 Britstown

6-1-n/...

TABLE 3. PARTICULARS OF COLLECTION SITES (Continued)

LOCALITY NUMBER	DESCRIPTION OF LOCALITY AND SITE	½° REFERENCE °S °E	MIN ALT (m) MAX ALT (m) RAINFALL IN dm	CADASTRAL INFORMATION. MAGISTERIAL DISTRICT
768 6-1-n	6 km W of Britstown. Low dolerite outcrop. Gentle NW *to* N *slope, with large dolerite boulders and* outcrops. W and E faces of boulders examined.	3023 CB 30°35.0' 23°27.0'	1150 1160 2-3	Gemsbokfontein Co.Q2A-79 Britstown
768 6-2-n	32 km W of Britstown, SSE facing slope. Dolerite.	3023 CA 30°37.6' 23°13.7'	1140 1160 2-3	Huisfontein Co.Q.28-89 Britstown
768 6-3-n	38 km W of Britstown, hill opposite Victoria West turnoff. Small Ecca exposure well up the hill, slightly caved krans. Scattered dolerite.	3023 CA 30°39.3' 23°10.5'	1110 1160 2-3	Platkuil V.W.Q.2-12 Britstown
768 6-4-n	51 km SW of Vosburg; Elandsfonteinkop, △63; High koppie with scattered dolerite boulders. S facing slope with lichens.	3022 CD 30°47.7' 22°26.9'	1310 1400 2-3	Elandsfontein A 4155/1958 (Houden-beck) Carnarvon
768 6-5-n	18 km NE of Carnarvon; *Kareebospoort; cave with* massive dolerite outcrops. S to W dolerite cliffs examined.	3022 CD 30°54.0' 22°15.6'	1280 1310 2-3	*Kareebosch-Fontein* Bf.W.Q3-63 *Carnarvon*
768 7-1-n	15 km W of Carnarvon; S-SE facing low Ecca siltstone krans.	3021 DD 30°59.7' 21°59.3'	1220 1370 1.5-2	Biesjies Laagte Lot No.2 Car Q.3-14 Carnarvon.

7-2-n/...

TABLE 3. PARTICULARS OF COLLECTION SITES (Continued)

LOCALITY NUMBER	DESCRIPTION OF LOCALITY AND SITE	¼ °REFERENCE °S °E	MIN ALT (m) MAX ALT (m) RAINFALL IN dm	CADASTRAL INFORMATION. MAGISTERIAL DISTRICT
768 7-2- n	40 km WSW of Carnarvon; Klipheuvels; most lichens on the S side of a dolerite boulder pile/hillock.	3121 BB 31°04.3' 21°48.2'	1310 1330 1.5-2	Klipheuvels 519 Carnarvon
768 7-3- n	48 km ENE of Williston; Low S facing Ecca sandstone krans.	3121 AD 31°15.4' 21°22.8'	1140 1160 1-1.5	Schuinshoogte Fr.Q.1-17 Williston
768 7-4-n	13 km ENE of Williston; Soutpanspoort; Gentle N facing slope, but S sides of large dolerite boulders with lichens.	3121 AC 31°16.9' 21°00.8'	1160 1170 1-1.5	Bokvlakte Fr.Q.7-21 Williston
768 7-5-n	24 km NW of Williston; Large dolerite boulders on ± level terrain.	3120 BB 31°10' 20°48'	1070 1220 1-1.5	- Williston
768 7-6- n	62 km NW of Williston. Scattered dolerite boulders on a gentle S facing slope.	3020 DC 30°55' 20°35'	910 1070 1-1.5	- Williston
768 8-1- n	64 km SW of Kenhardt; dolerite boulder pile/hillock.	2920 DB 29°43' 20°51'	880 900 1-1.5	- Kenhardt

8-2- n/. . .

TABLE 3. PARTICULARS OF COLLECTION SITES (Continued)

LOCALITY NUMBER	DESCRIPTION OF LOCALITY AND SITE	½ °REFERENCE °S °E	MIN ALT (m) MAX ALT (m) RAINFALL IN dm	CADASTRAL INFORMATION. MAGISTERIAL DISTRICT.
768 8-2- n	21 km SW of Kenhardt; Large granite boulders and a quartzite outcrop further up the gentle N facing slope examined. (No Xanthoparmeliae) (Botha et al.,(1976)	2921 AC 29°29.2' 21°02.2'	910 940 1-1.5	De bakken Ken. Q3-25 Kenhardt
768 8-3- n	10 km SW of Kenhardt, near Pofadder turnoff; small grey gneiss hill. (Botha et al.,(1976)	2921 AC 29°04.3' 21°09.0'	870 880 1-1.5	Driekop Oost CRCT 118/1942 Kenhardt
768 8-4- n	24 km N of Kenhardt; N'Rougasberg; S side of this mountain had Xanthoparmeliae. Quartzo-felspathic rock with a crumbly texture and orange-brown colour. (Botha et al.(1976).	2921 AA 29°08.3' 21°09.6'	850 880 1-1.5	N'Rougas Noord Kenhardt
768 8-5- n	29 km SSE of Keimoes; near Piet Rooisberg, △7; Pink coloured granite outcrop. SW and S sides of outcrop with lichens.	2821 CC 28°56.7' 21°05.8'	940 1040 1-1.5	Piet Rooi's Puts. Car. Q.4-4 Kenhardt
768 8-6- n	10 km SSE of Keimoes; Large granite boulder pile on the west side of the road. Lichens on S and SW sides of the pile.	2821 CC 28°47' 21°01'	760 910 1.5-2	- Gordonia
768 8-7- n	11 km E of Kakamas; Neusberg, Neuspoort; S facing steep slope examined. (No lichens) (Von Backström, 1964).	2820 DA 28°43.9' 20°42.3'	720 750 1.5-2	Zwart Boois Berg Gor Q.2-48 Gordonia

8-8- n/..

TABLE 3. PARTICULARS OF COLLECTION SITES *(Continued)*

LOCALITY NUMBER	DESCRIPTION OF LOCALITY AND SITE	½ °REFERENCE °S °E	MIN ALT (m) MAX ALT (m) RAINFALL IN dm	CADASTRAL INFORMATION. MAGISTERIAL DISTRICT
768 8-8- n	8 km E of Kakamas; Bobbejaanskrans Pass/Baviaanskrans Pass; Mica Schist Krans, with W to SW aspect. (Von Backström, 1964).	2820 DA 28°44.8' 20°41.05'	700 760 1-1.5	Zwart Boois Berg Gor Q.2-48 Gordonia
768 9-1- n	21 km W S W of Kakamas. Quartzite mountain E→S→W slopes examined. No lichens seen.	2820 CD 28°56.7' 20°20.1'	820 880 1-1.5	Marias Vlei Ken.Q.4-16 Kenhardt
768 9-2- n	38 km NE of Pofadder. S side of an E-W directed elongate dolerite boulder pile with abundant Xanthoparmeliae.	2819 DC 28°58.8' 19°43.1'	920 1070 0.5-1	Lucas Vlei Ken.Q3-13 Kenhardt
768 9-3- n	8 km ENE of Pofadder. Coarse grained gneissic rock.	2919 AB 29°07' 19°28'	910 1070 0.5-1	- Kenhardt
768 9-4-n	32 km SSE of Pofadder; S side of an E-W directed low quartz ridge, with lichens.	2919 BC 29°21.0' 19°31.6'	1040 1050 0.5-1	Steenkamps-Vlei Ken. Q8-11 Kenhardt
768 9-5-n	59 km N of Kliprand. Flat terrain with abundant pebbles of many different types.	3018 BB 30°07' 18°47'	910 1070 1	- Namaqualand 9-6- n/. . .

TABLE 3. PARTICULARS OF COLLECTION SITES (Continued)

LOCALITY NUMBER	DESCRIPTION OF LOCALITY AND SITE	½°REFERENCE °S °E	MIN ALT (m) MAX ALT (m) RAINFALL IN dm	CADASTRAL INFORMATION. MAGISTERIAL DISTRICT
768 9-6- n	6 km S of Kliprand, lichens on S to SE side of a granite outcrop near the road. (Albat, 1979).	3018 DA 30°39.0' 18°42.9'	780 800 1-1.5	Obeeb 2276/1918 Obeeb 8 Vanrhynsdorp
768 9-7- n	10 km S of Kliprand, NW to W facing slope examined with scattered granite boulders. (Albat, 1979).	3018 DA 30°40.3' 18°42.4'	780 800 1-1.5	Obeeb 2276/1918 Uitkyk 9 Vanrhynsdorp
768 10-1- n	42 km NE of Vanrhynsdorp; half way up Vanrhyns Pass; west facing slope, with Table Mountain sandstone (TMS) outcrops.	3119 AC 31°23.0' 19°01.2'	460 610 3-4	Vierfontein Clw.Q3-15 Vanrhynsdorp
768 10-2- n	45 km NE of Vanrhynsdorp, top of Vanrhyns Pass; west facing cliffs of Table Mountain sandstone, both vertical faces and horizontal top examined.	3119 AC 31°22.3' 19°01.05'	800 3-4	Meulsteen Vley Ext. 646. Clv.Q31-17 Calvinia
768 10-3- n	34 km NE of Clanwilliam, Klipfonteinrant.	3219 AA 32°04.0' 19°06.0'	300 460 1-1.5	Pakhuys, Tul. Q28-61 Clanwilliam
768 11-1- n	12 km WNW of Algeria; Rondegat river Valley; Table Mountain sandstone outcrop in valley examined.	3219 AC 32°18.8' 19°00.9'	760 915 6-8	Grootkloof Clanwilliam

11-2- n/...

TABLE 3. PARTICULARS OF COLLECTION SITES (Continued)

LOCALITY NUMBER	DESCRIPTION OF LOCALITY AND SITE	$\frac{1}{4}$°REFERENCE °S °E	MIN ALT (m) MAX ALT (m) RAINFALL IN dm	CADASTRAL INFORMATION. MAGISTERIAL DISTRICT
768 11-2- n	3 km N of Groot river bridge, Grootrivierhoogte. E face examined. Orthoquartzite slope.	3219 CB 32°35.8' 19°22.1'	850 915 4-5	Vogelfontein (1915-1-11) Ceres
768 11-3- n	46 km ENE of Ceres; Bokkeveld shale outcrops, with S to W facing aspect.	3319 BC 33°17' 19°44.5'	±920 4-6	 Ceres
768 12-1- n	of Laingsburg; Small rise ith a S aspect. e.	3321 AB 33°07.5' 21°17.5'	610 760 1-1.5	- Laingsburg
768 12-2- n	72 km ENE of Laingsburg. Low Beaufort mudstone exposures in dry stream valley.	3321 BA 33°04' 21°35.5'	305 455 1-1.5	- Prince Albert
768 12-3- n	*13 km N of Beaufort West, Molteno Pass; S & W aspects examined. Large dolerite outcrops.*	3222 BA 32°11.9' 22°33.2'	1400 1460 2 - 3	*Alwins Gat. Bf.W.Q6-37 Beaufort West*
768 12-4- n	*82 km NE of Beaufort West, Three Sisters; S facing dolerite sprinkled slope, with dolerite capping; opposite Railway station. N slope with X.brunnthaleri.*	3123 CC 31°53.0' 23°05.4'	1140 1240 2 - 3	*Groot Klip Victoria West*

772/..

TABLE 3. PARTICULARS OF COLLECTION SITES (Continued)

LOCALITY NUMBER	DESCRIPTION OF LOCALITY AND SITE	¼ °REFERENCE °S °E	MIN ALT (m) MAX ALT (m) RAINFALL IN dm	CADASTRAL INFORMATION. MAGISTERIAL DISTRICT
772 1-1-n	18 km NNE of Prieska. S to W facing Dwyka shale krans. (No lichens)	2922 DB 29°32' 22°46'	±1220 2-3	Kransfontein Hay.Q3-10 Prieska
772 1-2-n	20 km WNW of Upington, Seeppotkoppie; small granite hill, S side with lichens. "Colston granite".	2821 AC 28°24.2' 21°06.4'	870 890 1.5-2	Upington Allotment area Gordonia
772 1-3-n	86 km WNW of Upington, granite hills on S side of road. S side with the odd lichen present. (Geringer & Botha 1977, a & b).	2820 AD 28°16' 20°28'	760 910 1.0-1.5	Smalvisch Gordonia
772 1-4-n	5 km E of SWA border, granitic hills on S side of road. S side with the odd lichen. (Xanthoparmeliae absent). (Geringer & Botha, 1977a)	2820 AA 28°06' 20°03'	720 730 1.0-1.5	Arias Gordonia
772 2-1-n	78 km ESE of Karasburg. (No lichens).	2819 Ab 28°05.5' 19°29'	760 910 -	- SWA
772 2-2-n	37 km S of Grunow. Granite hill, X.brunnthaleri sparse on S side, no other lichens found.			- SWA

2-3-n/. . .

TABLE 3.PARTICULARS OF COLLECTION SITES (Continued)

LOCALITY NUMBER	DESCRIPTION OF LOCALITY AND SITE	$\frac{1}{4}^{o}$REFERENCE °S °E	MIN ALT (m) MAX ALT (m) RAINFALL IN dm	CADASTRAL INFORMATION. MAGISTERIAL DISTRICT
772 2-3-n	11 km S of the Orange River bridge at Vioolsdrif, no lichens found on any aspect of this hill. (Von Backström & de Villiers, 1972; Reid, 1977)	2817 DC 28°49.3' 17°41.2'	340 370 -	Vioolsdrift South Gr 235/1948 Namaqualand
772 2-4-n	29 km N of Springbok, Vriesklooflhoogte/Ratelpoort. Lichens abundant on W to S slopes/faces of white gneiss hill. (Clifford et al., 1975)	2917 BD 29°25.4' 17°49.3'	880 940 1.5-2	Steinkopf 2061/1950 Namaqualand
772 3-1-n	58 km W S W of Pofadder, near Gaamberg; No lichens on this quartzite hill. (Moore, 1977)	2918 BD 29°16.7' 18°57.4'	860 900 0.5-1	Bloemhoek. Nam. Q5-27 Namaqualand
772 3-2-n	40 km NW of Pofadder. Achab se berge (part of Namiesberg). S facing quartzo-felspathic outcrop examined. (Crumbly textured, pinky brown colour) Moore, 1977	2919 AC 29°17.1' 19°05.0'	960 1040 0.5-1	Kykgat Namaqualand
772 3-3-n	8 km NE of Graanaatboskelk (Brandvlei turnoff). Low dolerite exposure near the road; Lichens mostly on S side of exposure and boulders, and few on W side also.	2919 DD 29°58' 19°53'	910 1060 0.5-1	- Calvinia
772 3-4-n	6 km S of Loeriesfontein, Kubiskouberge. E to S slopes *examined. Dolerite outcrop and boulders.*	3019 CD 30°59.8' 19°29.1'	880 900 1.5-2	Erf 675.Gr 159/1938 Calvinia

4-1-n/...

TABLE 3. PARTICULARS OF COLLECTION SITES (Continued)

LOCALITY NUMBER	DESCRIPTION OF LOCALITY AND SITE	$\frac{1}{4}$° REFERENCE °S °E	MIN ALT (m) MAX ALT (m) RAINFALL IN dm	CADASTRAL INFORMATION. MAGISTERIAL DISTRICT
772 4-1-n	48 km NW of Middelpos, dolerite outcrop on the side of the road. Lichens on S side of outcrop.	3120 CA 31°36' 20°02'	915 1220 1.5-2	- Calvinia
772 4-2-n	11 km ESE Middelpos. Sandstone-siltstone exposure, Beaufort. S to W slopes/faces with abundant lichens.	3120 CD 31°58.3' 20°19.2'	1250 1280 2-3	Mullersfontein Wor.Q9-9 Sutherland
772 4-3-n	60 km SW of Sutherland, Tanqua river valley; gentle N slope strewn with dolerite boulders.	3220 DC 32°48.4' 20°32.8'	820 850 1.5-2	Karee Bosch Su.Q1-9 Sutherland
772 4-4-n	34 km N of Matjiesfontein; Turck's Pass, W facing Ecca krans	3220 DC 32°56.6' 20°33.4'	1200 1235 2-3	Bon Espirange Laingsburg
772 8-1-n	26 km S of Clanwilliam, Olifants river valley. E & W facing banks examined. Table Mountain sandstone	3218 BD 32°24.3' 18°57.3'	400 600 4	La Rhyn 1945.239 -11932 Clanwilliam
772 8-2-n	20 km ENE of Clanwilliam; Top of Pakhuis Pass; Table Mountain sandstone outcrops near road. W faces with most abundant lichen growth.	3219 AA 32°09.0' 19°01.8'	880 915 5-6	Bothas Berg Clanwilliam

8-3- n/. . .

TABLE 3. PARTICULARS OF COLLECTION SITES (Continued)

LOCALITY NUMBER	DESCRIPTION OF LOCALITY AND SITE	½ °REFERENCE °S °E	MIN ALT (m) MAX ALT (m) RAINFALL IN dm	CADASTRAL INFORMATION. MAGISTERIAL DISTRICT
772 8-3-n	11 km NE of Clanwilliam, Pakhuis Pass. Table Mountain sandstone and minor granite outcrop. S to W faces with most abundant lichen growth.	3218 BB 32°08.7' 18°57.0'	610 670 3-4	Klein Kliphuis Clw Q12-10 Clanwilliam
772 9-1-n	20 km SSE of Garies. SW to W slopes of a mountain with low streaky augen gneiss outcrops. (Joubert 1971)	3018 CA 30°42.5' 18°04.7'	360 380 1.5-2	Buffelsfontein Clw.Q7-22 Namaqualand
772 9-2-n	19 km S of Kamieskroon, Garagams/Karkams. Low gneiss ridge on E side of road. Lichens on W faces.	3017 BD 30°22.0' 17°53.9'	760 790 2-3	Leliefontein Clw F1-24 Namaqualand
772 9-3-n	45 km NE of Vanrhynsdorp; Top of Vanrhyns Pass; Table Mountain sandstone cliff faces and tops. W faces with the most abundant lichen growth.	3119 AC 31°22.3' 19°01.05'	800 3-4	Meulsteen Vley Clv.Q31-17 Calvinia
772 10-1-n	53 km W of Williston; Low dolerite outcrop, on the N side of the road. Lichens on S faces.	3120 AD 31°27' 20°24.5'	±1070 1-1.5	- Calvinia
772 10-2-n	34 km W of Williston, Jan Swartsberge. S to SE facing slopes of a dolerite strewn koppie.	3120 BC 31°23.0' 20°35.5'	1170 1200 1-1.5	Leeuwe Riet Fr.Q13-30 Williston

10-3-n/ . . .

TABLE 3. PARTICULARS OF COLLECTION SITES (Continued)

LOCALITY NUMBER	DESCRIPTION OF LOCALITY AND SITE	¼°REFERENCE °S °E	MIN ALT (m) MAX ALT (m) RAINFALL IN dm	CADASTRAL INFORMATION. MAGISTERIAL DISTRICT
772 8-3-n	11 km NE of Clanwilliam, Pakhuis Pass. Table Mountain sandstone and minor granite outcrop. S to W faces with most abundant lichen growth.	3218 BB 32°08.7' 18°57.0'	610 670 3-4	Klein Kliphuis Clw Q12-10 Clanwilliam
772 9-1-n	20 km SSE of Garies. SW to W slopes of a mountain with low streaky augen gneiss outcrops. (Joubert 1971)	3018 CA 30°42.5' 18°04.7'	360 380 1,5-2	Buffelsfontein Clw.Q7-22 Namaqualand
772 9-2-n	19 km S of Kamieskroon, Garagams/Karkams. Low gneiss ridge on E side of road. Lichens on W faces.	3017 BD 30°22.0' 17°53.9'	760 790 2-3	Leliefontein Clw F1-24 Namaqualand
772 9-3-n	*45 km NE of Vanrhynsdorp; Top of Vanrhyns Pass; Table Mountain sandstone cliff faces and tops. W faces with the most abundant lichen growth.*	3119 AC 31°22.3' 19°01.05'	800 3-4	*Meulsteen Vley* *Clv.Q31-17* *Calvinia*
772 10-1-n	53 km W of Williston; Low dolerite outcrop, on the N side of the road. Lichens on S faces.	3120 AD 31°27' 20°24.5'	±1070 1-1.5	- Calvinia
772 10-2-n	*34 km W of Williston, Jan Swartsberge. S to SE facing slopes of a dolerite strewn koppie.*	3120 BC 31°23.0' 20°35.5'	1170 1200 1-1.5	*Leeuwe Riet* *Fr.Q13-30* *Williston*

10-3-n/ . . .

TABLE 3. PARTICULARS OF COLLECTION SITES (*Continued*)

LOCALITY NUMBER	DESCRIPTION OF LOCALITY AND SITE	¼°REFERENCE °S °E	MIN ALT (m) MAX ALT (m) RAINFALL IN dm	CADASTRAL INFORMATION. MAGISTERIAL DISTRICT
772 10-3- n	27 km NW of Fraserburg (On the old road, as a new tarred road was in preparation at the time of collection). Very gentle NE facing slope with several low Beaufort ledges.	3121 CB 31°40.2' 21°26.6'	1250 1265 1-1.5	Blydevooruitzicht Fraserburg
772 10-4- n	16 km SSE of Fraserburg. Boulder strewn dolerite koppie. Lichens common on SE to SW slopes.	3221 BA 32°02.9' 21°34.4'	1400 1430 1.5-2	Zaai Klipheuvels Fr. Q15-12 Fraserburg
772 10-5- n	37 km SSE of Fraserburg, well down Teekloof. S facing Beaufort mudstone krans examined.	3221 BA 32°12.2' 21°36.9'	1160 1220 1.5-2	1915.4-284 Fraserburg
772 11-1- n	18 km of Prince Albert, top of Swartberg Pass. E to S facing slopes/faces with most abundant lichens. W face not seen. Table Mountain sandstone and minor granite.	3322 AC 33°21.2' 22°02.8'	1550 1580 8-9	Waarboomberg 159/1935 Oudtshoorn
772 11-2- n	38 km SE of Laingsburg. S facing low krans, of Bokkeveld shale.	3321 AC 33°22.5' 21°06'	610 760 2-3	- Laingsburg
772 11-3- n	48 km WNW of Calitzdorp, Seven Weeks Poort. S facing slope with Table Mountain sandstone exposures.	3321 AD 33°23.2' 21°24.5'	915 945 5-8	Seven Weeks Poort B620/1879 Laingsburg

14-1- n/. . .

TABLE 3. PARTICULARS OF COLLECTION SITES (Continued)

LOCALITY	DESCRIPTION OF LOCALITY AND SITE	$\frac{1}{4}^{\circ}$ REFERENCE °S °E	MIN ALT (m) MAX ALT (m) RAINFALL IN dm	CADASTRAL INFORMATION. MAGESTERIAL DISTRICT
772 14-1-n	18 km N of de Rust. Meiringspoort. S facing slope and S faces with most abundant lichens. Bokkeveld shale.	3322 BC 33°22.25' 22°33.3'	640 730 1.5-2	Wilgamond Bf.W. Q5-9 Prince Albert
772 14-2-n	58 km WNW of Willowmore, S facing gentle slope with a low ledge of Ecca.	3322 BB 33°11' 22°52'	760 910 1-1.5	- Willowmore
772 14-3-n	14 km N of Willowmore, Perdepoort, S facing slope examined, with W & E facing quartzitic exposures.	3323 AB 33°10.95' 23°25.75'	850 880 2-3	Paarde Poort P.A.Q1-37 Willowmore
772 15-1-n	6 km SW of Graaff-Reinet, Munnikspoort. S facing low Beaufort mudstone krans.	3224 BC 31°17.8' 24°31.6'	810 825 3-4	G.R.F. 9-34 Graaff-Reinet
772 15-2-n	64 km NE of Graaff-Reinet, Lootsberg Pass. E facing Beaufort mudstone exposures.	3124 DD 31°50.0' 24°51.3'	1800 4-5	Newland (Venters Hoek) Co.Q5-42 Middelburg
772 15-3-n	27 km W of Victoria West, Gapkop. Dolerite strewn koppie.	3122 BD 31°22.5' 22°51'	1370 1400 2-3	Vingerfontein V.W.Q4-12 Victoria West

15-4-n/ . . .

TABLE 3. PARTICULARS OF COLLECTION SITES (Continued)

LOCALITY NUMBER	DESCRIPTION OF LOCALITY AND SITE	¼° REFERENCE °S °E	MIN ALT (*m*) MAX ALT (m) RAINFALL IN dm	CADASTRAL INFORMATION. MAGESTERIAL DISTRICT
772 15-4-n	3 km NNW *of Loxton. S to W facing low krans of* Beaufort mudstone/siltstone.	3122 AD 31°27.5' 22°20.5'	1370 1525 2-3	*Erf 359 Phesante* Fontein V.W.Q12-4 Victoria West
772 16-1-n	8 km N of Carnarvon. ESE facing slope, with dolerite boulders and capped with dolerite. Lichens scarce. X. brunnthaleri only present.	3022 CC 31°54' 22°07.7'	1200 1250 1-2	Gr. 13/1938 Carnarvon
772 16-2-n	24 km NNW of Carnarvon. ESE facing slope of dolerite with dolerite boulders on level ground also.	3022 CC 30°46.6' 22°03.8'	1130 1170 1-2	Gr. 214/1935 Carnarvon
772 16-3-n	62 km SSE of Kenhardt. Low dolerite exposure. (No lichens).	2921 CA 29°48' 21°22'	910 1070 1-1.5	- Kenhardt
772 16-4-n	22 km SSE of Kenhardt. Low granite exposure on the E side of the road. (No lichens). (Botha et al, 1976).	2921 CA 29°31' 21°14'	760 910 1-1.5	- Kenhardt
772 16-5-n	10 km SSE of Kenhardt. Granite koppie on E side of road. No lichens present. (Botha et al, 1976)	2921 CA 29°26' 21°11.5'	760 910 1-1.5	- Kenhardt 16-6-n/...

TABLE 3.PARTICULARS OF COLLECTION SITES (Continued)

LOCALITY NUMBER	DESCRIPTION OF LOCALITY AND SITE	$\frac{1}{4}^{o}$REFERENCE ^{o}S ^{o}E	MIN ALT (m) MAX ALT (m) RAINFALL IN dm	CADASTRAL INFORMATION. MAGESTERIAL DISTRICT
772 16-6-n	10 km E of Kleinbegin. Quartzite hills. S and SW slopes and faces with X.psoromifera, otherwise lichens rare. Kaaien quartzite (Botha et al, 1976).	2821 DD 28°55.0' 21°45.1'	940 980 1.5-2	Bokputs Kenhardt

TABLE 3. PARTICULARS OF COLLECTION SITES (Continued)

LOCALITY NUMBER	DESCRIPTION OF LOCALITY AND SITE	$\frac{1}{4}$°REFERENCE °S °E	MIN ALT (m) MAX ALT (m) RAINFALL IN dm	CADASTRAL INFORMATION. MAGESTERIAL DISTRICT
772 16-6-n	10 km E of Kleinbegin. Quartzite hills. S and SW slopes and faces with X. psoromifera, otherwise lichens rare. Kaaien quartzite (Botha et al, 1976).	2821 DD 28°55.0' 21°45.1'	940 980 1.5-2	Bokputs Kenhardt

TABLE 4

5.2 SITE SPECIES COMPOSITION (in quarter degree square number order)

2718CC.	772 2-2-n. *X. brunnthaleri* (t).
2817DC.	772 2-3-n. No lichens.
2819AB.	772 2-1-n. No lichens.
2819DC.	768 9-2-n. *X. brunnthaleri* (t); *X. psoromifera; X.worcesteri.*
2820AA.	772 1-4-n. No Xanthoparmeliae.
2820AD.	772 1-3-n. *X. scabrosa.*
2820CD.	768 9-1-n. No Xanthoparmeliae.
2820DA.	768 8-7-n. No lichens.
2820DA.	768 8-8-n. *X. psoromifera.*
2821AC.	772 1-2-n. *X. psoromifera.*
2821CC.	768 8-6-n. *X. psoromifera; X. scabrosa.*
2821CC.	768 8-5-n. *X. brunnthaleri* (barb.); *X. chalybaeizans, X. schenckiana; X. subconspersa.*
2821DD.	772 16-6-n. *X. psoromifera.*
2917BD.	772 2-4-n. *X. chalybaeizans; X. colorata; X. columnata; X. exornata; X. perspersa; X. schenckiana; X. subconspersa; X. tasmanica; X. worcesteri; O. hottentottum.*
2918BD.	772 3-1-n. No lichens.
2919AB.	768 9-3-n. *X. perspersa.*
2919AC.	772 3-2-n. *X. chalybaeizans; X. colorata; X. perspersa; X. schenckiana; X. subramigera; X. worcesteri.*
2919BC.	768 9-4-n. *X. brunnthaleri* (barb.); *X. exornata; X. subdecipiens.*
2919DD.	772 3-3-n. *X. brunnthaleri* (barb.); *X. psoromifera.*
2920DB.	768 8-1-n. *X. brunnthaleri* (barb.).

2921AA.	768 8-4-n. *X. brunnthaleri* (barb.); *X. psoromifera; X. worcesteri.*
2921AC.	768 8-3-n. No Xanthoparmeliae.
2921AC.	768 8-2-n. No lichens.
2921CA.	772 16-5-n. No lichens.
2921CA.	772 16-4-n. No lichens.
2921CA.	772 16-3-n. No lichens.
2922DB.	772 1-1-n. No lichens.
2923DC.	768 5-2-n. *X. brunnthaleri; X. dichromatica; X. leptoplaca.*
2923DD.	768 5-1-n. *X. brunnthaleri; X. leptoplaca; X. perspersa; X. worcesteri.*
3017BD.	772 9-2-n. *X. chalybaeizans; X. colorata; X. columnata; X. perspersa; X. schenckiana; X. subconspersa; X. worcesteri; O. hottentottum.*
3018BB.	768 9-5-n. *X. brunnthaleri* (barb.)
3018CA.	772 9-1-n. *X. chalybaeizans; X. colorata; X. exornata; X. hypoleia; X. molliuscula; X. perspersa; X. schenckiana; X. subconspersa; X. tasmanica; X. worcesteri; O. hottentottum.*
3018DA.	768 9-6-n. No Xanthoparmeliae, but abundant growth of other (mainly crustose) lichens.
3018DA.	768 9-7-n. *X. schenckiana, X. subconspersa.*
3019CD.	772 3-4-n. *X. chalybaeizans, X. colorata; X. exornata; X. hypoleia; X. perspersa; X. schenckiana; X subconspersa; X. tasmanica; O. hottentottum.*
3020DC.	768 7-6-n. *X. brunnthaleri* (barb.); *X. worcesteri.*
3021DD.	768 7-1-n. *X. leptoplaca; X. perspersa; X. schenckiana; X. worcesteri.*
3022CC.	772 16-2-n. *X. brunnthaleri* (barb.); *X. schenckiana.*
3022CC.	772 16-1-n. *X. brunnthaleri* (t); *X. leptoplaca.*

3022CD. 768 6-4-n. *X. perspersa.*

3022CD. 768 6-5-n. *X. leptoplaca; X. perspersa; X. schenckiana.*

3023BA. 768 5-3-n. *X. brunnthaleri* (barb.); *X. exornata; X. leptoplaca; X. psoromifera; X. subconspersa; X. worcesteri.*

3023BA. 768 5-4-n. No lichens.

3023BC. 768 5-5-n. *X. brunnthaleri* (barb.); *X. leptoplaca.*

3023CA. 768 6-2-n. *X. dichromatica, X. leptoplaca.*

3023CA. 768 6-3-n. No Xanthoparmelise.

3023CB. 768 6-1-n. *X. brunnthaleri.*

3119AC. 768 10-2-n. *X. chalybaeizans; X. constrictans; X. exornata; X. hypoleia; X. perspersa; X. subconspersa; X. tasmanica.*

3119AC. 772 9-3-n. *X. chalybaeizans; X. colorata; X. exornata; X. hypoleia; X. tasmanica.*

3119AC. 768 10-1-n. *X. chalybaeizans; X. colorata; X. hypoprotocetrarica; X. ianthina; X. perspersa; X. subconspersa; O. hottentottum.*

3120AD. 772 10-1-n. *X. brunnthaleri* (barb.); *X. leptoplaca; X. schenckiana.*

3120BB. 768 7-5-n. *X. brunnthaleri; X. leptoplaca; X. schenckiana; X. subdecipiens.*

3120BC. 772 10-2-n. *X. brunnthaleri* (t); *X. chalybaeizans; X. dichromatica; X. leptoplaca; X. perspersa; X. schenckiana; X. subconspersa; X. worcesteri.*

3120CA. 772 4-1-n. *X. chalybaeizans; X. exornata; X. leptoplaca; X. perspersa; X. schenckiana; X. worcesteri.*

3120CD. 772 4-2-n. *X. chalybaeizans; X. colorata; X. exornata; X. hypoleia; X. leptoplaca; X. perspersa; X. schenckiana; X. tasmanica; X. worcesteri; O. hottentottum.*

3121AC. 768 7-4-n. *X. brunnthaleri* (t); *X. leptoplaca; X. perspersa.*

31_1AD. 768 7-3-n. *X. leptoplaca, X. perspersa.*

3121BB. 768 7-2-n. *X. brunnthaleri* (barb.); *X. dichromatica; X. leptoplaca.*

3121CB. 772 10-3-n. *X. brunnthaleri* (barb.); *X. dichromatica; X. schenckiana; X. worcesteri.*

3122AD. 772 15-4-n. *X. dichromatica; X. leptoplaca; X. perspersa; X. schenckiana.*

3122BD. 772 15-3-n. *X. brunnthaleri* (barb.); *X. dichromatica; X. leptoplaca; X. schenckiana.*

3123CC. 768 12-4-n. *X. brunnthaleri* (t); *X. chalybaeizans; X. exornata; X. leptoplaca; X. perspersa; X. schenckiana; X. subconspersa; X. subdecipiens; X. worcesteri.*

3124DD. 772 15-2-n. *X. chalybaeizans; X. exornata; X. heterodoxa; X. leptoplaca; X. perspersa; X. psoromifera; X. schenckiana; X. subconspersa; X. subdecipiens; X. worcesteri; O. hottentottum.*

3218BB. 772 8-3-n. *X. adhaerens; X. chalybaeizans; X. exornata; X. hypoleia; X. hypoprotocetrarica; X. hyporhytida; X. perspersa; X. psoromifera; O. hottentottum.*

3218BD. 772 8-1-n. *X. chalybaeizans; X. colorata; X. dysprosa; X. globulifera; X. hypoleia; X. hypomelaena; X. hypoprotocetrarica; X. ianthina; X. perspersa; X. psoromifera; X. subconspersa; O. hottentottum.*

3219AA. 768 10-3-n. *X. chalybaeizans; X. columnata; X. hypoleia; X. hypomelaena; X. perspersa; X. schenckiana; X. subconspersa; X. subdecipiens; X. tasmanica.*

3219AA. 772 8-2-n. *X. chalybaeizans; X. columnata; X. hypoleia; X. hypomelaena; X. perspersa; X. squamatica; X. subconspersa; X. tasmanica; O. hottentottum.*

3219AC. 768 11-1-n. *X. hypomelaena; X. hypoprotocetrarica; X. perspersa; X. ralla; X. subconspersa.*

3219CB. 768 11-2-n. *X. chalybaeizans; X. colorata; X. exornata; X. schenckiana; X. subconspersa; X. worcesteri.*

3220DC. 772 4-3-n. *X. chalybaeizans; X. schenckiana; X. subconspersa; X. subdecipiens; O. hottentottum.*

3220DC. 772 4-4-n. *X. chalybaeizans; X. leptoplaca; X. perspersa; X. psoromifera; X. schenckiana; X. tasmanica; X. worcesteri; O. hottentottum.*

3221BA. 772 10-4-n. *X. brunnthaleri* (t); *X. colorata; X. exornata; X. leptoplaca; X. psoromifera; X. schenckiana; X. subconspersa; X. tasmanica; O. hottentottum.*

3221BA. 772 10-5-n. *X. chalybaeizans; X. dichromatica; X. leptoplaca; X. perspersa; X. subconspersa; O. hottentottum.*

3222BA. 768 12-3-n. *X. chalybaeizans; X. exornata; X. perspersa; X. worcesteri.*

3224BC. 772 15-1-n. *X. perspersa; X. subconspersa.*

3319BC. 768 11-3-n. *X. chalybaeizans; X. perspersa; X. schenckiana; X. subconspersa; X. tasmanica.*

3321AB. 768 12-1-n. *X. perspersa.*

3321AC. 772 11-2-n. *X. chalybaeizans; X. colorata; X. schenckiana.*

3321AD. 772 11-3-n. *X. adhaerens; X. burmeisteri; X. chalybaeizans; X. constrictans; X. dichromatica; X. endomiltodes; X. exornata; X. globulifera; X. heterodoxa; X. hypoleia; X. hypomelaena; X. molliuscula; X. perspersa; X. ralla; X. subconspersa; X. subdecipiens; O. hottentottum.*

3321BA. 768 12-2-n. *X. perspersa.*

3322AC. 772 11-1-n. *X. adhaerens; X. chalybaeizans; X. conspersa; X. constrictans; X. hypoleia; X. hypoprotocetrarica; X. subconspersa; O. hottentottum.*

3322BB. 772 14-2-n. *X. chalybaeizans; X. perspersa* (atypical);
X. schenckiana.

3322BC. 772 14-1-n. *X. chalybaeizans; X. exornata; X. globulifera;*
X. hypoprotocetrarica; X. leucostigma; X. perspersa; X.
subconspersa; X. subdecipiens; X. worcesteri.

3323AB. 772 14-3-n. *X. adhaerens; X. dichromatica; X. exornata;*
X. leptoplaca; X. perspersa.

5.3 STEINER'S STABLE PARAPHENYLENEDIAMINE (1,4-DIAMINOBENZENE) SOLUTION. (STEINER, 1955)

0.1 g p-phenylenediamine

1.0 g sodium sulphite

10 ml water

0.1 ml liquid detergent.

Paraphenylenediamine is usually somewhat brownish (oxidized), and has to be cleaned using small successive aliquots of 95% ethanol, and the brown supernatant discarded. The cleaned crystals can then be dissolved in 5 ml of 95% ethanol and made up to 10 ml with water. The sodium sulphite is then dissolved and the liquid detergent added.

An alternative procedure is dissolving the cleaned crystals in 10 ml of 10% sodium sulphite solution in pure water, followed by 0.1 ml of liquid detergent. The former procedure gave the best results. The solution is satisfactory for at least a month.

5.4 PLATES

PLATE 1

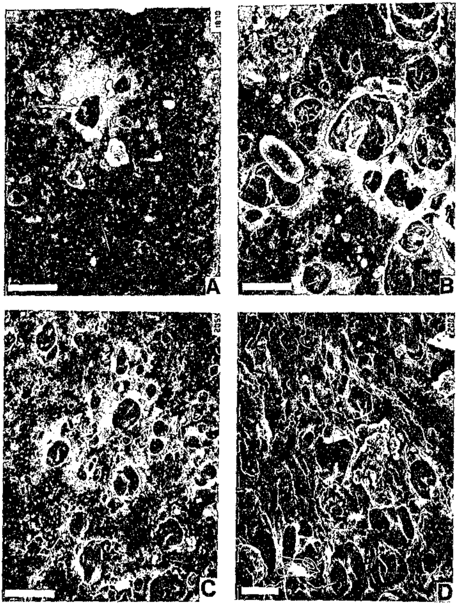


PLATE 1

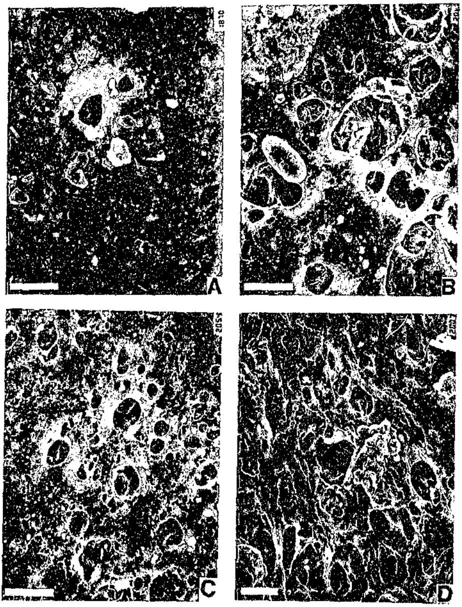


PLATE 1

A. Sparsely pored epicortex of *X. endomiltodes* (Nyl.) Hale, 772 11-3-16 (Bar = 10 µm).

B. Pored epicortex of *X. chalybaeizans* (J. Stein. et Zahlbr.) Hale, 772 8-1-1 pp., with an ascospore on the upper surface (Bar = 10 µm).

C. Pored epicortex of *X. psoromifera* (Kurok.) Hale, 772 8-4-1 (Bar = 10 µm).

D. Pored epicortex of *X. hypoprotocetrarica* (Kurok. et Elix) Hale, 772 8-1-17 (Bar = 10 µm).

PLATE 2

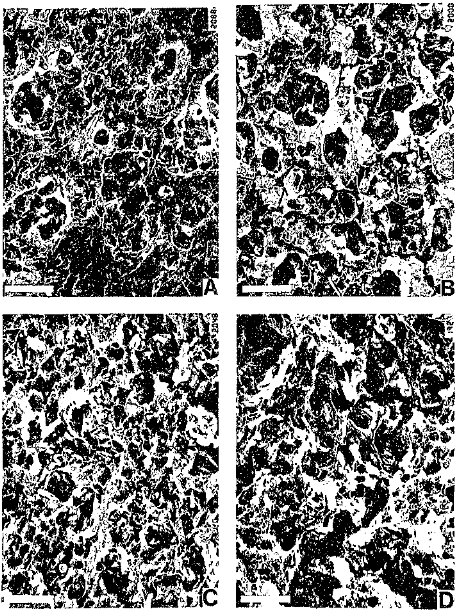


PLATE 2

A. Pored epicortex of *X. chalybaeizans* (J. Stein. et Zahlbr.) Hale, 772 14-2-5, (Bar = 10 µm).

B. Pored epicortex of *X. dysprosa* Brusse, 772 8-1-6 (Bar = 10 µm).

C. Highly pored epicortex of *X. psoromifera* (Kurok.) Hale, 772 1-2-1, (Bar = 10 µm).

D. Rudimentary epicortex of *X. perspersa* (Stiz.) Brusse, 772 15-2-25 pp (Bar = 10 µm).

PLATE 3

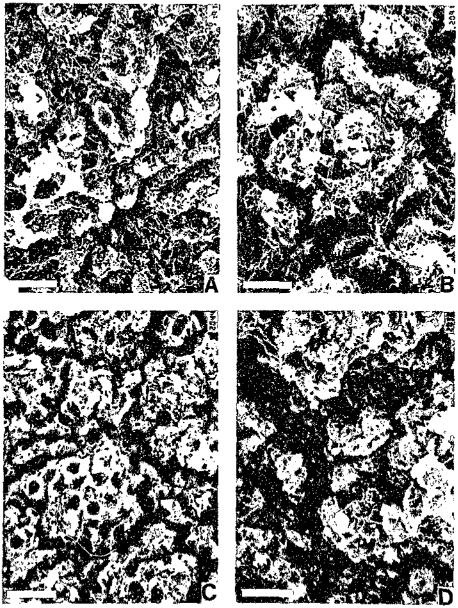


PLATE 3

A. Rudimentary epicortex of *X. persperea* (*Stiz.*) Brusse, 772 8-1-1 pp, (Bar = 10 µm).

B. Rudimentary epicortex of *X. chalybaeizans* (*J. Stein.* et Zahlbr.) Hale, 772 9-1-8, (Bar = 10 µm).

C. Rudimentary epicortex of *X. colorata* (Gyel.) Hale, 772 11-2-6, (Bar = 10 µm) (or upper cortex remains).

D. Rudimentary epicortex of *X. colorata* (Gyel.) Hale, 772 4-2-17, clearly showing the hyphal tips of the upper cortex between the pieces of epicortex tissue (Bar = 10 µm).

PLATE 4

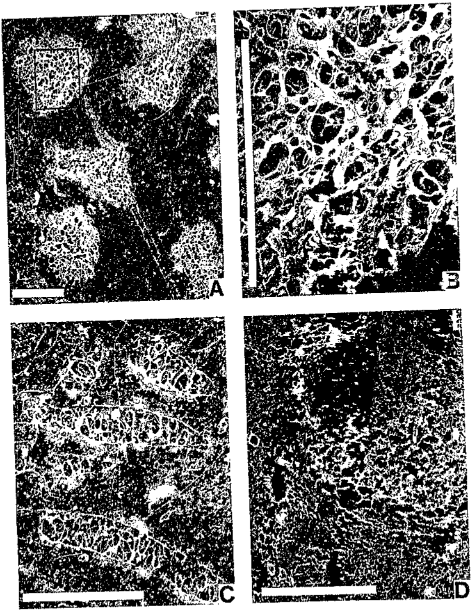


PLATE 4

A. Highly pored areas on an otherwise unpored epicortex of *X. exornata* (Zahlbr.) Brusse, 768 11-2-2, (Bar = 100 µm).

B. Close up of the highly pored area framed in Plate 4A, (Bar = 100 µm).

C. Elongated pored areas in the epicortex of *X. exornata* (Zahlbr.) Brusse near the lobe tip. 772 3-4-28. (Bar = 100 µm).

D. A somewhat sunken pored area on a microwrinkled epicortex of *X. exornata* (Zahlbr.) Brusse, 772 8-3-7 (Bar = 100 µm).

PLATE 5

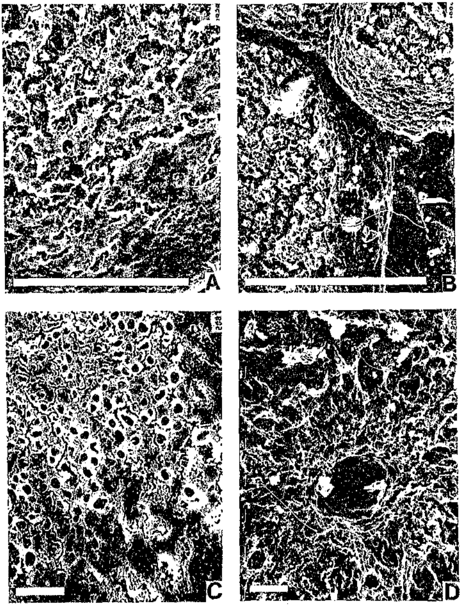


PLATE 5

A. Scanning electron micrograph of the lobe tip of *X. persperea* (Stiz.) Brusse 772 15-2-25, showing the initially epicorticate surface rapidly becoming rudimentary (Bar = 1 mm).

B. SEMicrograph of *X. ralla* Brusse, showing the epicorticate sides of lobes and the rudimentary epicortex of the upper surface. 772 11-3-3 pp. (Bar = 100 µm).

C. Scratch on the upper cortex of *X. chalybaeizans* (J. Stein. et Zahlbr.) Hale (772 15-2-17) showing the ± vertically orientated hyphae (Bar = 10 µm).

D. Ostiole of a pycnium on the upper surface of *X. subconspersa* (Nyl.) Hale, 772 11-3-35 (Bar = 10 µm).

PLATE 6

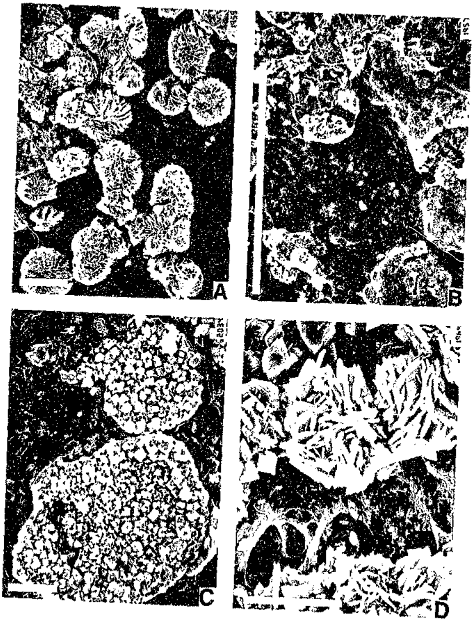


PLATE 6

A. Crystal rosettes on the lobe tip upper surface of *X. perspersa* (Stiz.) Brusse, 772 8-1-2 (Bar = 10 μm).

B. Epicortical blisters on the lobe tip of *X. persperea* (Stiz.) Brusse, 772 8-1-2 (Bar = 100 μm).

C. Clusters of pyramidal or bipyramidal crystals on the lobe tip upper surface of *X. exornata* (Zahlbr.) Brusse. 772 11-3-45. (Bar = 10 μm).

D. Coarse plate rosettes and distorted cubic crystals on the lobe tip upper surface of *X. perspersa* (Stiz.) Brusse, 768 6-5-2 (Bar = 10 μm).

PLATE 7

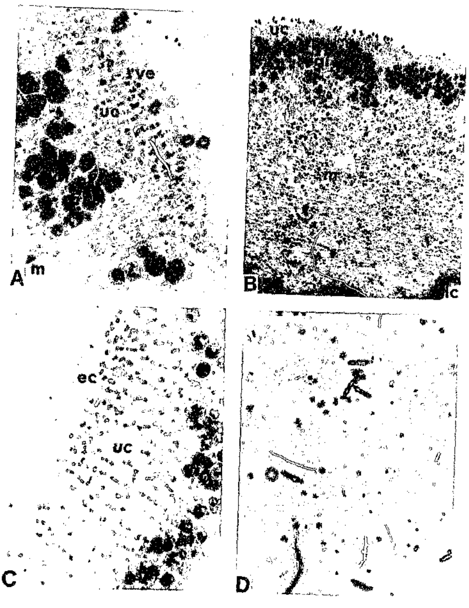


PLATE 7 *PHOTOMICROGRAPHS OF XANTHOPARMELIA MATERIAL STAINED IN* PHLOXINE WITH BLUE LIGHT ILLUMINATION

A. L/S of the upper cortex of *X. schenckiana* (Müll. Arg.) Hale (Usnic acid removed) x800.

B. L/S of the lobe of *X. schenckiana* (Müll. Arg.) Hale x200.

C. L/S of the upper cortex of *X. hypoleia* (Nyl.) Hale (772 11-3-41) showing the scleroplectenchymatous nature of this layer. (Usnic acid removed) x600.

D. Pycnoconidia of *X. columnata* Hale (768 10-3-7) x1300.

Legend: al = algal layer; ec = epicortex; lc = lower cortex; m = medulla; uc = upper cortex; ve = rudimentary epicortex.

PLATE 8

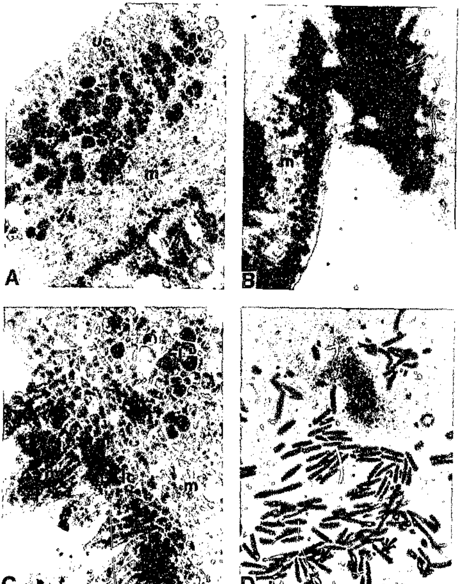


PLATE 8 PHOTOMICROGRAPHS OF *X. LEPTOPLACA* (ZAHLBR.) BRUSSE MATERIAL STAINED IN PHLOXINE WITH BLUE LIGHT ILLUMINATION.

A. L/S lobe of *X. leptoplaca* (Zahlbr.) Brusse, showing the lower cortex becoming less and less distinct towards the interior (the right). x800.

B. L/S of the lower cortex of *X. leptoplaca* (Zahlbr.) Brusse, near the tip of the lobe. x800.

C. L/S of the lower cortex of *X. leptoplaca* (Zahlbr.) Brusse, showing the hyphal extentions, (Rudimentary rhizines?) x830.

D. Pycnoconidia of *X. leptoplaca* (Zahlbr.) Brusse x1300. Arrows pointing to pycnoconidia with 4 swellings.

Legend: al = algal layer; he = hyphal extensions; lc= lower cortex; m = medulla; uc = upper cortex.

PLATE 9

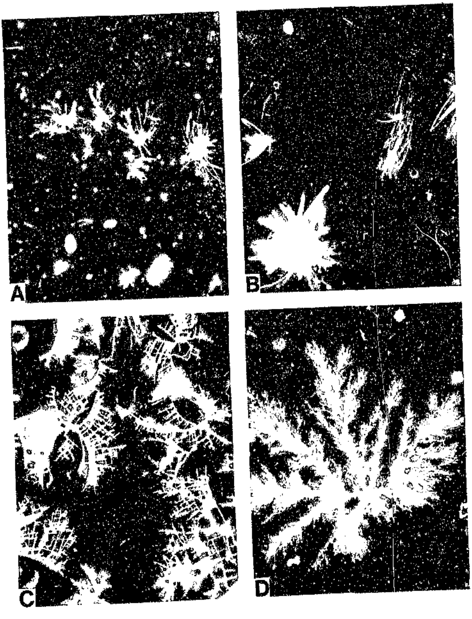


PLATE 9 Photomicrographs of recrystallized lichen substances using dark field illumination.

A. Barbatic acid in GAoT, x160, from the acetone extract of *X. brunnthaleri* (J. Stein. et Zahlbr.) Hale 768 8-4-4.

B. Barbatic acid in GAoT, x640, from the acetone extract of *X. burmeisteri* (Elix) Brusse. 772 11-3-18a.

C. Divaricatic acid in GAW (Culberson, 1963), x200, from the acetone extract of *Neofuscelia pulla* (Ach.) Essl., 768 10-1-16.

D. Thamnolic acid in GAAn, x100, from the acetone extract of *X. hypomelaena* (Vain. ex Lynge) Brusse, 772 11-3-9.

PLATE 10

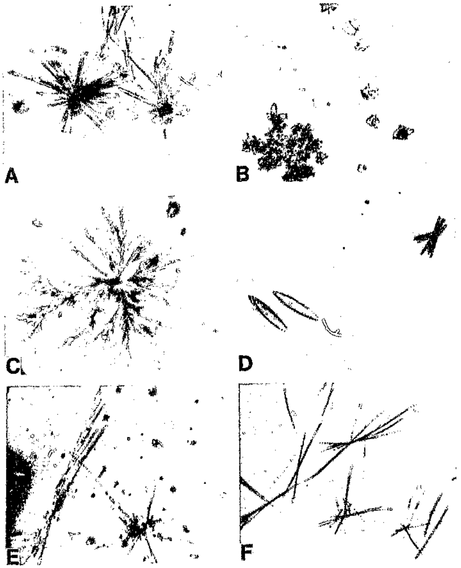


PLATE 10 Photomicrographs of recrystallized lichen substances using normal illumination.

A. Unidentified substance in GAoT (either barbatic or 4-O-demethylbarbatic acids or both), x100, from the acetone extract of *X. burmeisteri* (Elix) Brusse 772 11-3-18a.

B. Barbatic acid in GE, x130, from the acetone extract of benzene extracted *X. burmeisteri* (Elix) Brusse, 772 11-3-18a.

C. Lecanoric acid in GAW, x130, from the acetone extract of *X. worcesteri* (J. Stein. et Zahlbr.) Hale, 772 3-2-5.

D. Salazinic acid in GAoT, x320, from the acetone extract of *X. tasmanica* (Hook.f. et Tayl.) Hale, 772 3-4-14.

E. Usnic acid in GE, x130, from the acetone extract of *X. psoromifera* (Kurok.) Hale, 772 1-2-5.

F. Atranorin in GAoT, x85, from the acetone extract of *Heterodermia boryi* (Fe) Hale.

PLATE 11

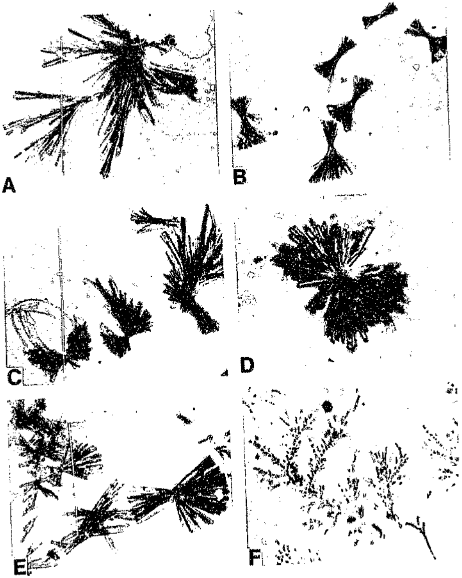


PLATE 11 Photomicrographs of recrystallized lichen substances using normal illumination.

A, B, C. *Hypoprotocetraric* acid in GWPy, x80, from the acetone extract of benzene extracted *X. perspersa* (Stiz.) Brusse, 772 15-4-16.

D & E. Hypoprotocetraric acid in GE, x160, from the acetone extract of benzene extracted *X. perspersa* (Stiz.) Brusse, 772 15-4-16.

F. Protolichesterinic acid-like crystals in GE, x160, from the acetone extract of benzene extracted *X. perspersa* (Stiz.) Brusse, 772 15-4-16.

PLATE 12

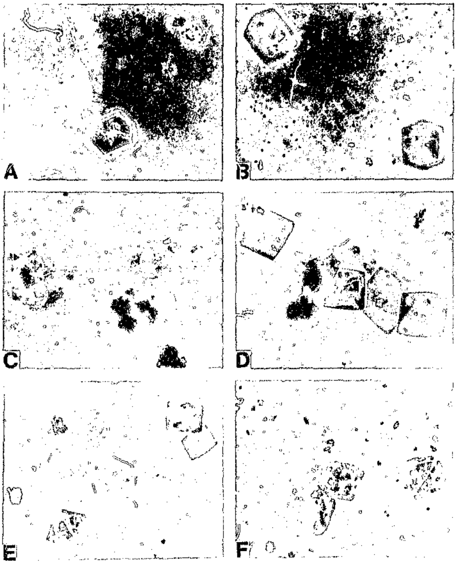


PLATE 12 Photomicrographs of recrystallized lichen substances using phase contrast illumination.

A. Hexagonal plate of stictic acid in GAot, x400, from the acetone extract of *X. molliuscula* (Ach.) Hale, 772 9-1-32.

B. Hexagonal plates of stictic acid in GAot, x650, from the acetone extract of *X. molliuscula* (Ach.) Hale, 772 9-1-32.

C. Rosettes of square plates of norstictic acid in GAot, x390, from the acetone extract of *Omphalodium hottentottum* (Ach.) Flot., 772 4-4-14.

D. Square plates of norstictic acid in GAot, x460, from the acetone extract of *O. hottentottum* (Ach.) Flot., 772 4-4-14.

E. Staggered square plates of norstictic acid in GAot, x460, from the acetone extract of *O. hottentottum* (Ach.) Flot., 772 4-4-14.

F. Staggered square plate clusters of norstictic acid in GAot, x450, from the acetone extract of *O. hottentottum* (Ach.) Fw., 772 4-4-14.

PLATE 13

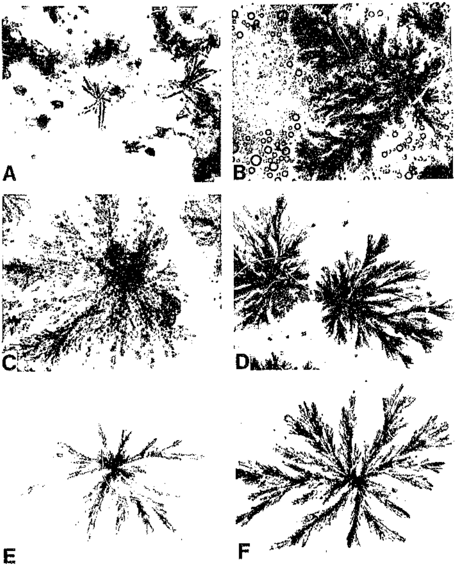


PLATE 13 Photomicrographs of recrystallized lichen substances using normal illumination.

A. Squamatic acid in GAAn, x130, from the acetone extract of benzene extracted *X. hypomelaena* (Vain. ex Lynge) Brusse, 772 8-2-9.

B. Unidentified substance Th-1 in GAAn, x80, from the acetone extract of benzene extracted *X. hypomelaena* (Vain. ex Lynge) Brusse, 772 8-2-9.

C. Psoromic acid in GE, x80, from *Rhizocarpon geographicum* (L.) DC, 768 10-2-8.

D. Psoromic acid in GE, x80, from *Rhizocarpon geographicum* (L.) DC, 768 10-2-8.

E. Evernic acid in GE, x80, from *X. dysprosa* Brusse, 772 8-1-6.

F. Evernic acid in GE, x80, from *X. dysprosa* Brusse, 772 8-1-6.

PLATE 14

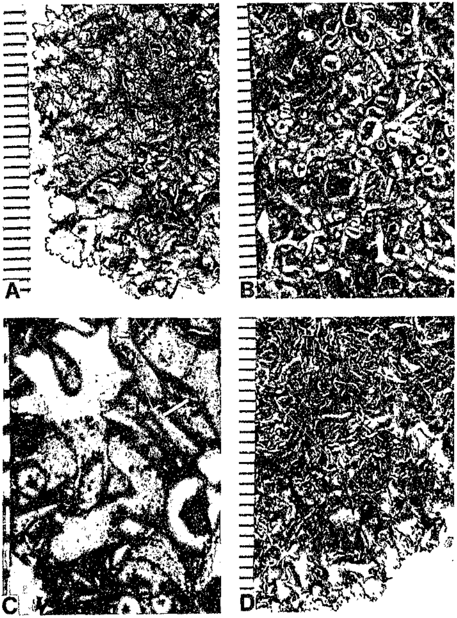


PLATE 14 (All scales in mm for now onwards)

A. *X. hypoleia* (Nyl.) Hale 772 9-3-7.

B. *X. hypoleia* (Nyl.) Hale 768 10-2-4.

C. *X. hypoleia* (Nyl.) Hale 768 10-2-4.

D. *X. hypoleia* (Nyl.) Hale 772 11-3-41.

PLATE 15

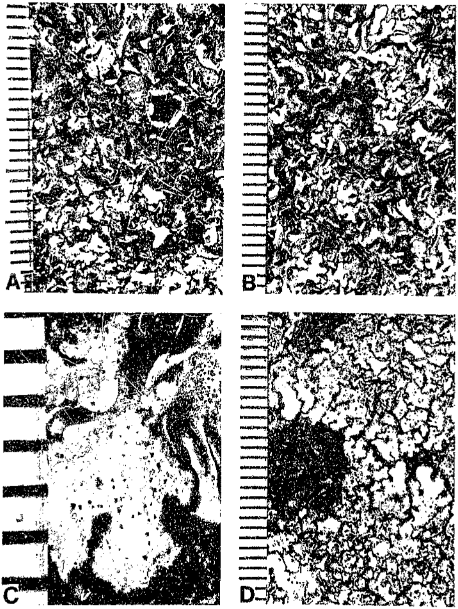


PLATE 15

A. *X. hypoprotocetrarica* (Kurok. et Elix) Hale 768 11-1-2.

B. *X. hypoprotocetrarica* (Kurok. et Elix) Hale 772 8-1-17.

C. *X. hypoprotocetrarica* (Kurok. et Elix) Hale 768 10-1-7.

D. *X. exornata* (Zahlbr.) Brusse 772 14-1-28.

PLATE 16

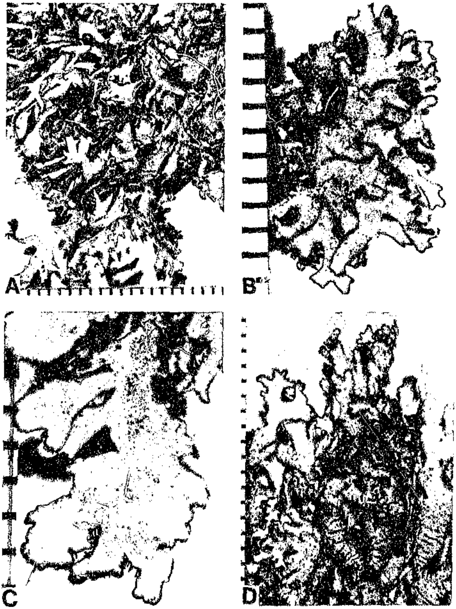


PLATE 16

A. *X. hypomelaena* (Vain. ex Lynge) Brusse 772 11-3-9.

B. *X. hypomelaena* (Vain. ex Lynge) Brus. 772 8-2-19.

C. *X. hypomelaena* (Vain. ex Lynge) Brusse 772 8-2-9.

D. *X. hypomelaena* (Vain. ex Lynge) Brusse 772 8-2-9.

PLATE 17

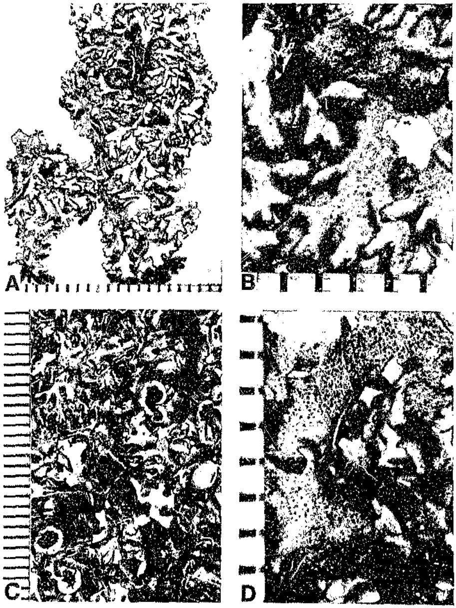


PLATE 17

A. *X. burmeisteri* (Elix) Brusse 772 11-3-18a.

B. *X. burmeisteri* (Elix) Brusse 772 11-3-18a.

C. *X. dysprosa* Brusse 772 8-1-6.

D. *X. dysprosa* Brusse 772 8-1-6.

PLATE 18

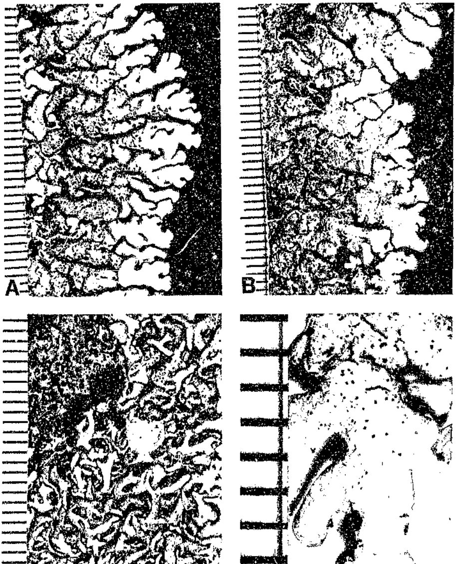


PLATE 18

A. *X. exornata* (Zahlbr.) Brusse 768 12-3-1.

B. *X. exornata* (Zahlbr.) Brusse 768 5-3-2.

C. *X. exornata* (Zahlbr.) Brusse 772 11-3-10.

D. *X. exornata* (Zahlbr.) Brusse 772 10-4-9 showing the heavy maculation, and the filamentous surface growth occurring widely on these lichens.

PLATE 19

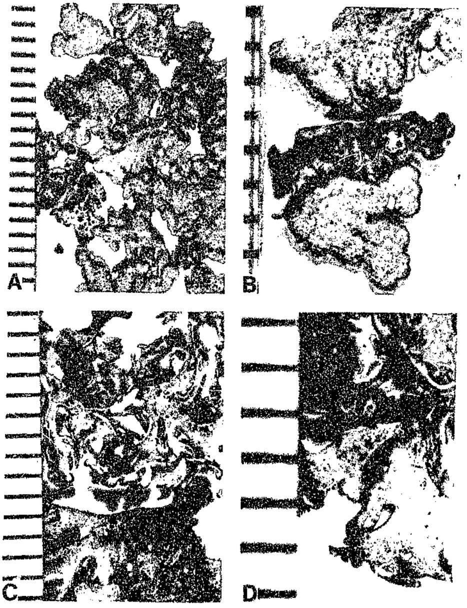


PLATE 19

A. *X. leucostigma* Brusse 772 14-1-13.

B. *X. leucostigma* Brusse 772 14-1-13.

C. *X. hyporhytida* (Hale) Hale 772 8-3-14 pp.

D. *X. hyporhytida* (Hale) Hale 772 8-3-14 pp.

PLATE 20

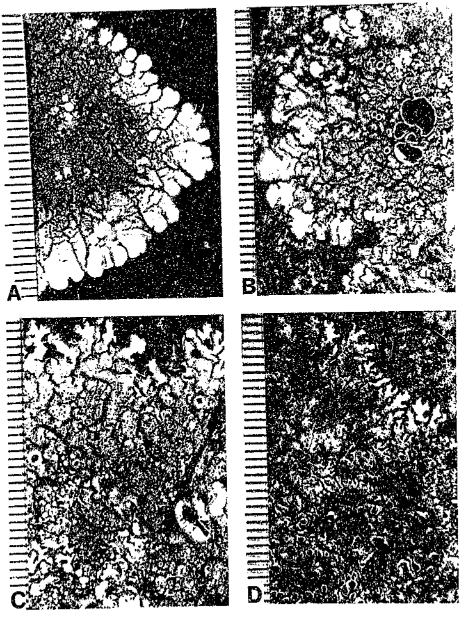


PLATE 20

A. *X. chalybaeizans* (J. Stein. et Zahlbr.) Hale 772 11-2-4.

B. *X. chalybaeizans* (J. Stein. et Zahlbr.) Hale 772 9-3-6.

C. *X. chalybaeizans* (J. Stein. et Zahlbr.) Hale 772 11-2-7.

D. *X. chalybaeizans* (J. Stein. et Zahlbr.) Hale 772 8-3-3.

PLATE 21

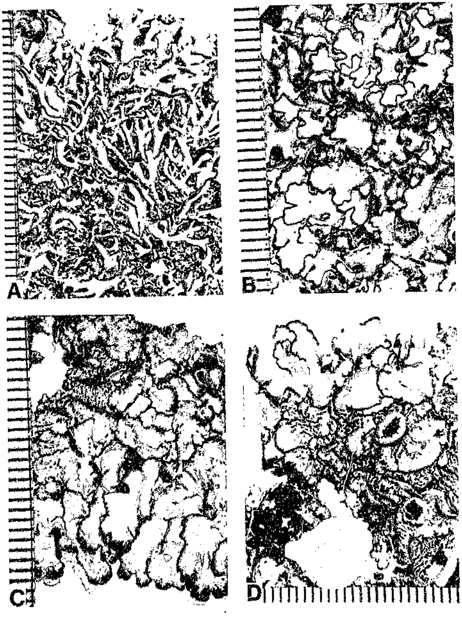


PLATE 21

A. *X. subconspersa* (Nyl.) Hale 768 11-3-3.

B. *X. subconspersa* (Nyl.) Hale 772 11-3-36.

C. *X. subconspersa* (Nyl.) Hale 772 9-2-8.

D. *X. subconspersa* (Nyl.) Hale 772 10-5-8.

PLATE 22

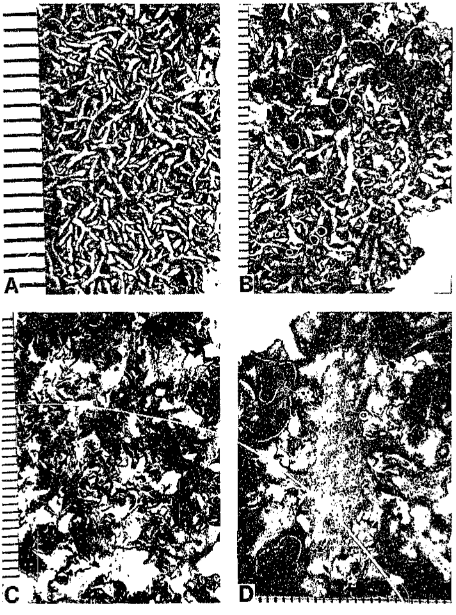


PLATE 22 A. *X. constrictans* (Nyl.) Hale 772 11-3-27.

B. *X. constrictans* (Nyl.) Hale 772 11-1-23.

C. *X. subconspersa* (Nyl.) Hale 772 9-2-16.

D. *X. subconspersa* (Nyl.) Hale 768 10-3-4 on the thallus of *Omphalodium hottentottum* (Ach.) Flot.

PLATE 23

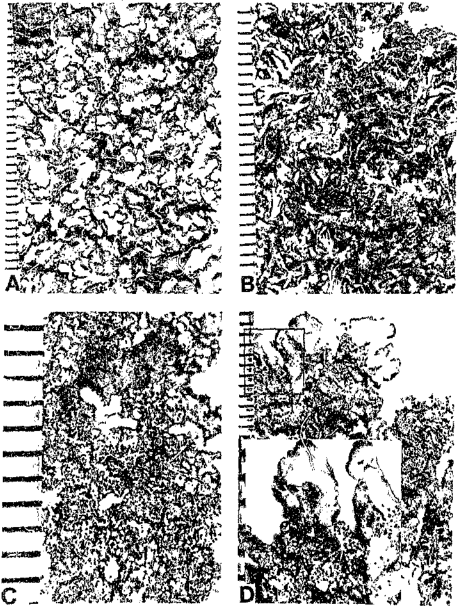


PLATE 23

A. *X. subconspersa* (Nyl.) Hale 772 10-2-10.

B. *X. subconspersa* (Nyl.) Hale 772 8-3-8.

C. *X. conspersa* (Ach.) Hale 772 11-1-9.

D. *X. globulifera* (Kurok. et Filson) Brusse 772 11-3-31.

PLATE 24

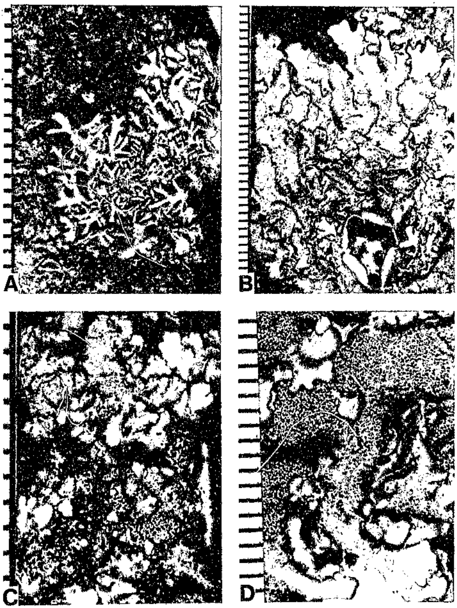


PLATE 24

A. *X. molliuscula* (Ach.) Hale 772 9-1-35.

B. *X. tasmanica* (Hook.f. et Tayl.) Hale 768 10-2-15.

C. *X. scabrosa* (Tayl.) Hale 772 1-3-1.

D. *X. subramigera* (Gyel.) Hale 772 3-2-10.

PLATE 25

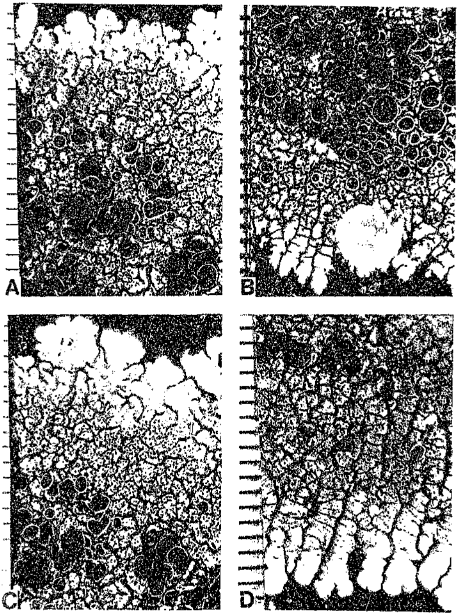


PLATE 25

A. *X. brunnthaleri* (J. Stein. et Zahlbr.) Hale 768 5-5-4.

B. *X. brunnthaleri* (J. Stein. et Zahlbr.) Hale 772 15-3-8.

C. *X. brunnthaleri* (J. Stein. et Zahlbr.) Hale 768 5-5-4.

D. *X. brunnthaleri* (J. Stein. et Zahlbr.) Hale 772 10-2-3.

PLATE 26

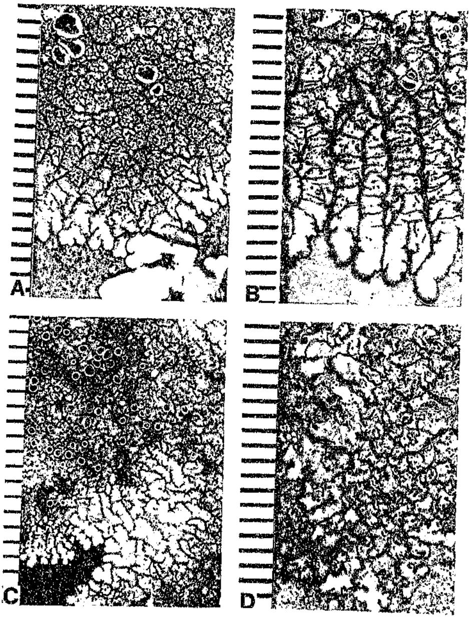


PLATE 26

A. *X. perspersa* (Stiz.) Brusse. A specimen with an unusual medullary chemistry. 772 14-2-4.

B. *X. perspersa* (Stiz.) Brusse 772 8-1-2.

C. *X. worcesteri* (J. Stein. et Zahlbr.) Hale 772 14-1-3A.

D. *X. ianthina* Brusse 768 10-1-15.

PLATE 27

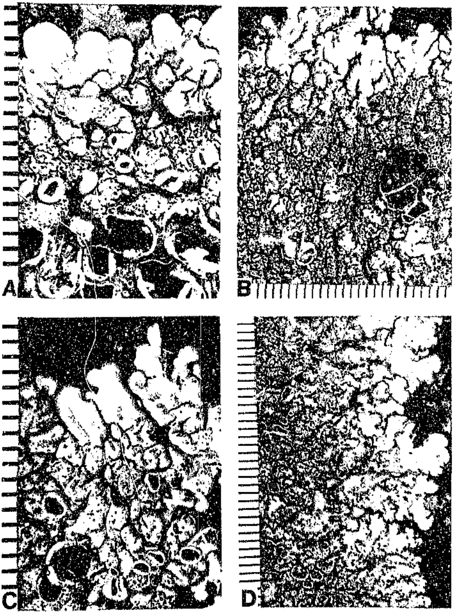


PLATE 27 A. *X. dichromatica* (Hale) Hale 768 7-2-4.

B. *X. dichromatica* (Hale) Hale 772 15-3-9.

C. *X. subdecipiens* (Vain. ex Lynge) Hale 768 9-4-2.

D. *X. subdecipiens* (Vain. ex Lynge) Hale 768 12-4-2.

PLATE 28

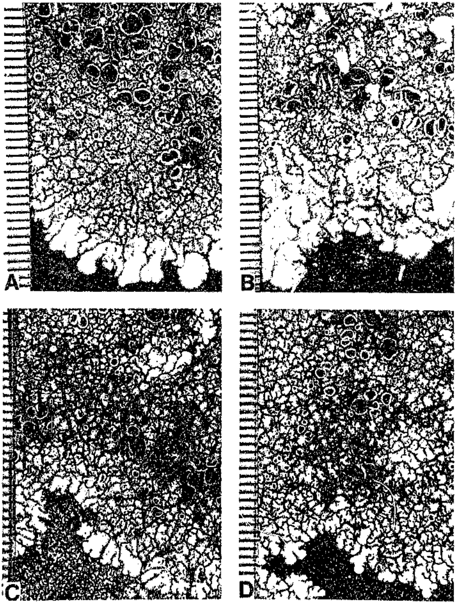


PLATE 28

A. *X. perspersa* (Stiz.) Brusse 772 14-3-2.

B. *X. perspersa* (Stiz.) Brusse 768 7-3-1.

C. *X. perspersa* (Stiz.) Brusse 772 15-2-6.

D. *X. perspersa* (Stiz.) Brusse 772 15-4-4.

PLATE 29

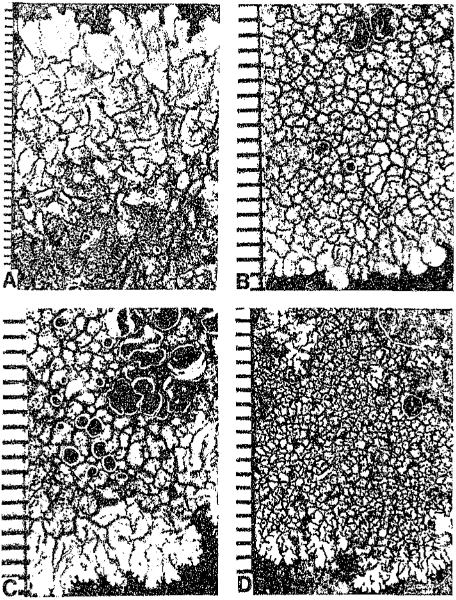


PLATE 29 A. *X. perspersa* (Stiz.) Brusse 772 14-3-8.

B. *X. perspersa* (Stiz.) Brusse 772 15-2-3.

C. *X. perspersa* (Stiz.) Brusse 768 10-1-22.

D. *X. perspersa* (Stiz.) Brusse 768 10-3-2.

PLATE 30

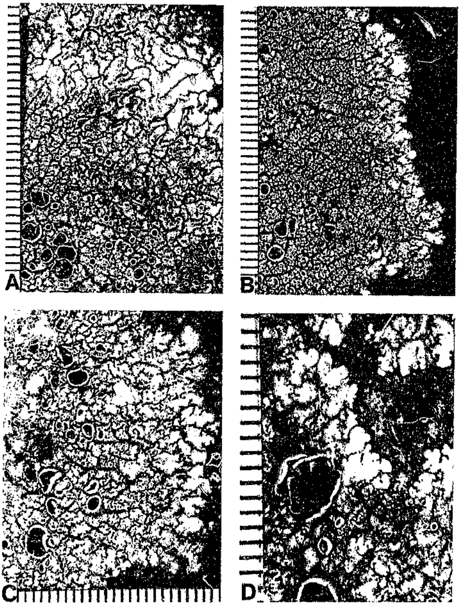


PLATE 30

A. *X. worcesteri* (J. Stein. et Zahlbr.) Hale 768 5-3-1.

B. *X. worcesteri* (J. Stein. et Zahlbr.) Hale 768 5-3-1. The same specimen, but growing on a shoulder of a rock, with the one side broad lobed and the other narrow lobed and coarse-pruinose.

C. *X. worcesteri* (J. Stein. et Zahlbr.) Hale 772 2-4-1.

D. *X. worcesteri* (J. Stein. et Zahlbr.) Hale 772 3-2-5.

PLATE 31

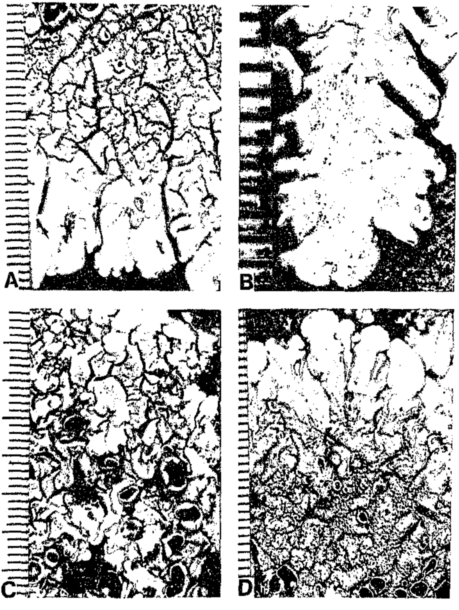


PLATE 31

A. *X. schenckiana* (Müll. Arg.) Hale 768 6-5-3.

B. *X. schenckiana* (Müll. Arg.) Hale 772 15-4-5. taken with low angle illumination to show coarse-pruina.

C. *X. colorata* (Gyel.) Hale 772 11-2-1.

D. *X. psoromifera* (Kurok.) Hale 768 8-8-1.

PLATE 32

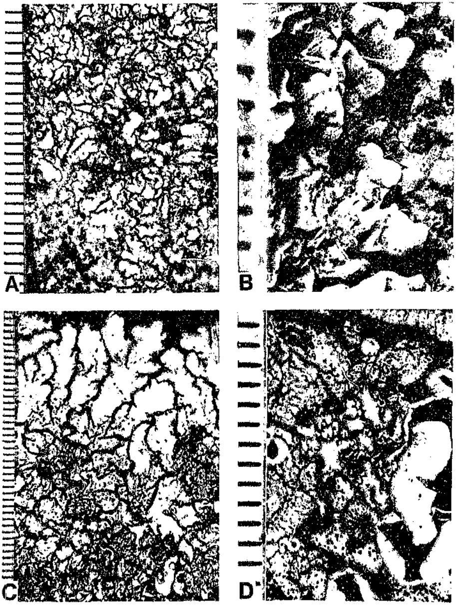


PLATE 32

A. *X. chalybaeizans* (J. Stein. et Zahlbr.) Hale, 772 2-4-2.

B. *X. chalybaeizans* (J. Stein. et Zahlbr.) Hale, 772 2-4-2, taken with low angle illumination, to show up the coarse-pruinose uppersurface.

C. *X. colorata* (Gyel.) Hale, 772 10-4-4.

D. *X. chalybaeizans* (J. Stein. et Zahlbr.) Hale growing on the surface *X. colorata* (Gyel.) Hale, 772 4-2-17.

PLATE 33

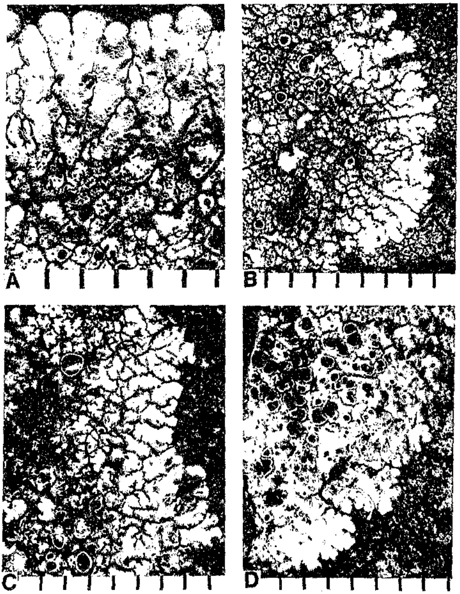


PLATE 33

A. *X. leptoplaca* (Zahlbr.) Brusse, typical crustose, habit, 772 10-5-1, with low angle illumination to show up coarse-pruina.

B. *X. leptoplaca* (Zahlbr.) Brusse, less frequent subcrustose habit, with well developed apothecia 772 10-4-5.

C. *X. leptoplaca* (Zahlbr.) Brusse, less frequent subcrustose habit, with well developed apothecia 772 10-4-1.

D. *X. leptoplaca* (Zahlbr.) Brusse, less frequent subcrustose habit, with well developed apothecia 772 15-3-4.

PLATE 34

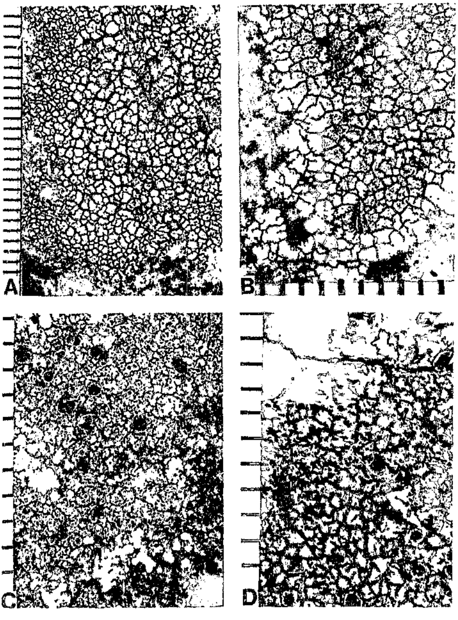


PLATE 34

A. *X. adhaerens* (Nyl.) Hale, 772 8-3-2, subcrustose form.

B. *X. adhaerens* (Nyl.) Hale, 772 11-3-2, crustose form.

C. *X. adhaerens* (Nyl.) Hale, 772 14-3-7, crustose form with well developed apothecia.

D. *X. constrictans* (Nyl.) Hale, 772, 11-1-4, crustose form.

PLATE 35

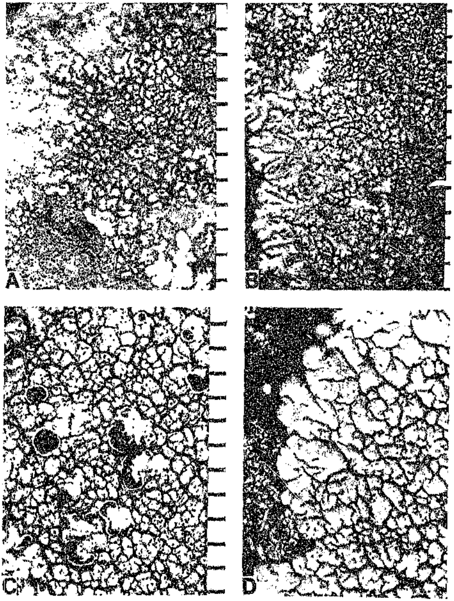


PLATE 35

A. *X. ralla* Brusse, 772 11-3-3 pp.

B. *X. heterodoxa* (Hale) Hale, 772 15-2-5.

C. *X. worcesteri* (J. Stein. et Zahlbr.) Hale, the interior of a subcrustose form, 768 5-1-5.

D. *X. worcesteri* (J. Stein. et Zahlbr.) Hale, lobate margin of the same thallus, 772 5-1-5 (Scale as in 35C).

PLATE 36

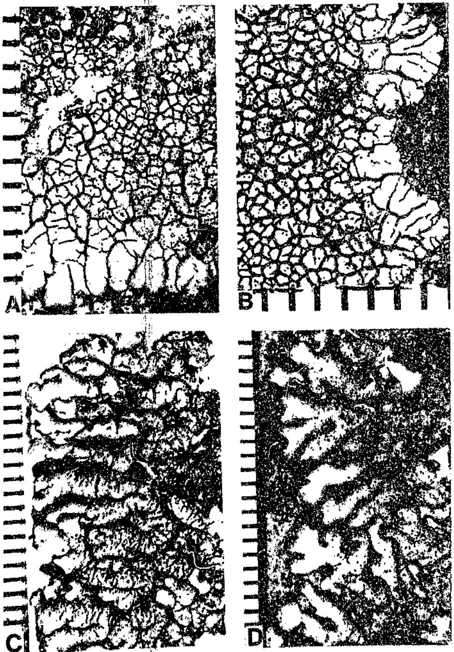


PLATE 36

A. *X. chalybaeizans* (J. Stein. et Zahlbr.) Hale 772 9-2-5.

B. *X. squamatica* Brusse 772 8-2-1.

C. *X. columnata* Hale 772 2-4-12.

D. *X. exornata* (Zahlbr.) Brusse 768 11-2-11.

6 LITERATURE CITED

des Abbayes, H. (1961) Lichens récoltés à Madagascar et à la Réunion (Mission H. des Abbayes, 1956). I. Introduction. II. Parméliaceés. Memoires de l'institute de Recherche Scientifique de Madagascar, Serie B, Biologie Vegetale, 10(2): 81-121.

Acharius, E. (1794) Försök til en förbättrad lafvarnes indelning. Kungliga Vetenskaps Academiens Nya Handlingar, 15: 237-259.

———— (1798) Lichenographiae Suecicae prodromus. D.G. Björn, Lincopiae. xxiv + 264 pp + 2 pls.

———— (1810) Lichenographia universalis. I.F. Dankwerts, Göttingae. viii + 696 pp + 14 pls.

Acocks, J.P.H. (1975) Veld Types of South Africa. Memoirs of the Botanical survey of South Africa (40).

———— (1979) The flora that matched the fauna. Bothalia, 12(4): 673-709.

Albat, H.M. (1979) Preliminary Report on the geology of the Kliprand area in Namaqualand. Annual Report of the Precambrian Research Unit, University of Cape Town, 16: 47-57.

Almborn, O. (1966) Revision of some lichen genera in southern Africa. Botaniska Notiser, 119: 71-112.

Anderson, A.M. and McLachlan, I.R. (1976) The plant record in the Dwyka and Ecca series (Permian) of the south-western half of the Great Karoo Basin, South Africa. Palaeontologia Africana, 19: 31-42.

Asahina, Y. (1936-40) Mikrochemischer Nachweis der Flechtenstoffe I-XI. Journal of Japanese Botany, 12: 516-525, 859-872; 13: 529-536, 855-861; 14: 39-44, 244-250, 318-323, 650-659, 767-773; 15: 465-472; 16: 185-193.

Awasthi, D.D. (1975) A monograph of the lichen genus *Dirinaria*. Bibliotheca lichenologia, 2.

von Backström, J. (1964) The geology of the area around Keimoes, with special reference to placoliths of charnockitic adamellite-porphyry. Memoirs of the Geological Survey of South Africa, 53: 1-218.

von Backström, J.W. and de Villiers, J. (1972) The geology along the Orange River between Onseepkans and the Richtersveld. Explanation sheets 2817D (Vioolsdrif) 2818C and D (Goodhouse) and 2819C (Onseepkans). The Geological Survey of South Africa.

Barr, M.E. (1976) Perspectives in the Ascomycotina. Memoirs of the New York Botanical Gardens, 28: 1-8.

Beg, W.R., Chester, D.O. and Elix, J.A. (1979) The structure of conorlobaridone and conloxodin. New depsidones from the lichen *Xanthoparmelia xanthosorediata*. Australian Journal of Chemistry, 32(4): 927-929.

Bendz, G., Santesson, J. and Wachtmeister, C.A. (1965) Studies on the chemistry of lichens 22. The chemistry of the genus *Siphula* I. Acta Chemica Scandinavica, 19(5): 1250-1252.

Blignaut, H.J. (1978) Structural-metamorphic imprint on part of the Namaqua Mobile Belt in South West Africa. Bulletin of the Precambrian Research Unit, University of Cape Town, 23,v + 197 pp.

Blum, O.B. (1973) Water Relations. pp. 381-400 in: Ahmadjian, V. and Hale, M.E. (Eds.) The Lichens. Academic Press, New York - London. xiv + 697 pp.

Bolus, H. (1875) Letter from Mr. Bolus to Dr. J.B. Hooker. Journal of the Linnean Society of London, *Botany*, *14:* 482-484.

Botha, B.J.V., Grobler, N.J., Lindstrom, W. and Smit, C.A. (1976) Stratigraphic correlation between the Kheis and Matsap formations and their relation to the Namaqualand Metamorphic Complex. Transactions of the Geological Society of South Africa, 79: 304-311.

——————————————————— (1977) Major structural features of the area between the Langeberg Range and Kenhardt, Northern Cape Province. Transactions of the Geological Society of South Africa, 80: 101-110.

Brodo, I.M. (1973) Substrate Ecology, pp. 401-441 in: Ahmadjian, V. and Hale, M.E. (Eds.) The Lichens. Academic Press, New York - London. xiv + 697 pp.

Bu'lock, J.D. (1967) Essays in biosynthesis and microbial development. Wiley and Sons. New York.

Buswell, J.A., Ander, P., Petterson, B. and Eriksson, K-E. (1979) Oxidative decarboxylation of vanillic acid by *Sporotrichum pulverulentum*. FEBS letters, 103(1): 98-101.

Buswell, J.A. and Eriksson, K-E. (1979) Aromatic ring cleavage by the white-rot fungus *Sporotrichum pulverulentum*. FEBS letters 104(2): 258-260.

Cerniglia, C.E., Herbert, R.L., Szaniszlo, P.J. and Gibson, D.T. (1978) Fungal Transformation of Napthalene. Archives of Microbiology, 117: 135-143.

Chester, D.O. and Elix, J.A. (1978) The identification of four new *meta*-depsides in the lichen *Ramalina asahinae*. Australian Journal of Chemistry, 31(12): 2745-2749.

Clarke, P.H. and Ornston, L.N. (1975) Metabolic Pathways and Regulation. 1 and 2, pp. 191-261 and 263-340 in: Clarke, P.H. and Richmond, M.H. (Eds.) "Genetics and Biochemistry of *Pseudomonas*". Wiley and Sons. London - New York - Sydney - Toronto. ix + 366 pp.

Clifford, T.N., Gronow, J , Rex, D.C. and Burger, A.J. (1975) Geochronological and petrogenic studies of high grade metamorphic rocks and intrusives in Namaqualand, South Africa. Journal of Petrology, 16: 154-188.

Corner, E.J.H. (1929) Studies in the Morphology of Discomycetes. II The structure and development of the ascocarp. Transactions of the British Mycological Society, 14: 275-291.

Cowan, D.A., Green, T.G.A. and Wilson, A.T. (1979) Lichen metabolism. 1. The use of tritium labelled water in studies of anhydrobiotic metabolism in *Ramalina celastri* and *Peltigera polydactyla*. New Phytologist, 82(2): 489-503.

Crombie, J.M. (1876) New lichens from the Cape of Good Hope. Journal of Botany British and Foreign, 14: 18-21.

——————— (1876) An enumeration of the lichens collected at the Cape of Good Hope by the Rev. A.E. Eaton during the Venus-Transit Expedition in 1874. Journal of the Linnean Society of London, Botany, 15: 165-180.

Culberson, C.F. (1963) The lichen substances of the genus *Evernia*. Phytochemistry, 2: 335-340.

——————— (1965) Some microchemical tests for the lichen depsidone hypoprotocetraric acid. The Bryologist, 68: 301-304.

——————— (1969a) Chemical and Botanical Guide to Lichen Products. University of North Carolina Press, Chapel Hill. ix + 628 pp.

——————— (1969b) Chemical studies in the genus *Lobaria* and the occurrence of a new tridepside, 4-O-methylgyrophoric acid. The Bryologist, 72: 19-27.

——————— (1970) Supplement to "Chemical and Botanical Guide to Lichen Products". The Bryologist, 73: 177-377.

——————— (1972) Improved conditions and new data for the identification of lichen products by a standardized thin-layer chromatographic method. Journal of Chromatography, 72: 113-125.

——————— (1974) Conditions for the use of Merck silica gel 60 F_{254} plates in the standardized thin-layer chromatographic technique for lichen products. Journal of Chromatography, 97: 107-108.

Culberson, C.F. and Culberson, W.L. (1976) Chemosyndromic variation in lichens. Systematic Botany, 1(4): 325-339.

——————————— (1978) β-Orcinol derivatives in lichens: Biogenetic Evidence from *Oropogon loxensis*. Experimental Mycology, 2: 245-257.

Culberson, C.F., Culberson, W.L. and Esslinger, T.L. (1977) Chemosyndromic variation in the *Parmelia pulla* group. The Bryologist, 80(1): 125-135.

Culberson, C.F., Culberson, W.L. and Johnson, A. (1977) Second supplement to "Chemical and botanical guide to lichen products". The American Bryological and Lichenological Society, St. Louis, Missouri. 400 pp.

Culberson, C.F. and Hale, M.E. (1973) 4-O-demethylnotatic acid; A new depsidone in some lichens producing hypoprotocetraric acid. The Bryologist, 76: 77-84.

Culberson, C.F. and Kristinsson, H-D. (1970) A standard method for the identification of lichen products. Journal of Chromatography, 46: 85-93.

Culberson, C.F., Nash, T.H. and Johnson, A. (1979) 3-α-Hydroxybarbatic acid, a new depside in chemosyndromes of some Xanthoparmeliae with β-orcinol depsides. The Bryologist, 82(2): 154-161.

Culberson, W.L. and Culberson, C.F. (1968) The lichen genera *Cetrelia* and *Platismatia* (Parmeliaceae). Contributions from the United States National Herbarium, 34(7): 449-558.

——————————— (1970) A phylogenetic view of chemical evolution in the lichens. The Bryologist, 70: 1-31.

Dimroth, P., Walter, H. and Lynen, F. (1970) Biosynthese von 6-methylsalicylsäure. European Journal of Biochemistry, 13(1): 98-110.

Dodge, C.W. (1959) Some lichens of tropical Africa III. Parmeliaceae. Annals of the Missouri Botanical Garden, 46(2): 39-193.

——————— (1971) Some lichens of tropical Africa V. Lecanoraceae to Physciaceae. Beihefte zur Nova Hedwigia, 38: 1-225.

Doelle, H.W. (1975) Bacterial Metabolism. Academic Press; New York - San Francisco - London; Ed. 2. xiii + 738 pp.

Egan, R.S. (1975) New *Xanthoparmelia* (Lichenes : Parmeliaceae) records from New Mexico. Mycotaxon, 2(2): 217-222.

Egan, R.S. and Derstine, K.S. (1978) A new species in the lichen genus *Xanthoparmelia* from Texas. Bryologist, 81(4): 605-608.

Elix, J.A. (1976) Three new species of *Parmelia* subgenus *Xanthoparmelia* from South Eastern Australia. Australian Journal of Botany, 24(5): 663-668.

Esslinger, T.L. (1973) Nomenclatural notes on some members of *Parmelia* section *Melanoparmelia*. The Bryologist, 76: 306-309.

——————— (1974) A chemosystematic revision of the brown *Parmeliae*. Ph.D. thesis, Duke University.

——————— (1977) A chemosystematic revision of the brown Parmeliae. Journal of the Hattori Botanical Laboratory [Hattori Shokubutsu Kenkyujo], (42): 1-211.

——————— (1978) A new status for the brown Parmelia. Mycotaxon, 7(1): 45-54.

Fahselt, D. (1979) Lichen substances of transplanted thallus segments of *Parmelia cumberlandia*. Canadian Journal of Botany, 57(1): 23-25.

Foo, L.Y. and Galloway, D.J. (1979) Pseudodepsidones and other constituents from *Xanthoparmelia scabrosa*. Phytochemistry, 18(12): 1977-1980.

Foo, L.Y. and *Gwyn, S.A. (1978) Identification of norlobariol, a new* lichen constituent from *Xanthoparmelia scabrosa* (Tayl.) Hale. Experientia, 34(8): 970.

Fox, C.H. and Mosbach, K. (1967) On the biosynthesis of lichen substances. Part 3. *Lichen acids as products of a symbiosis. Acta* Chemica Scandinavica, 21: 2327-2330.

Frege, C.G. (1812) Deutsches Botanisches Taschenbuch, v. 2. Zeiz.

Fries, E. (1825) Systema Orbis Vegetabilis, Pars 1, Plantae Homonemeae. Lundae vii + 374 pp.

Galloway, D.J. (1979) New Zealand Journal of Botany (in preparation).

Geringer, G.J. and Botha, B.J.V. (1977a) Anatektiese graniete in die Mobile Gordel Namakwaland wes van Upington. Geological Survey Bulletin, 61.

——————————— (1977b) The gneisses and regional structural pattern of the Namaqualand Mobile Belt in part of the Gordonia district, north-western Cape. Transactions of the geological Society of South Africa, 80: 93-96.

Gerson, U. *and Seaward, M.R.D. (1977) Lichen* - invertebrate associations pp. 69-119. in: Seaward, M.R.D. (ed.) Lichen Ecology. Academic Press. London - New York - San Francisco. x + 550 pp.

Goh, E.M. and Wilkins, A.L. (1979) Structures of the lichen depsidones granulatin and chlorogranulatin. *Journal of the Chemical* Society, Perkin Transactions I, 1979(6): 1656.

Green, T.G.A. and Snelgar, W.P. (1977) *Parmelia scabrosa* on glass in New Zealand. The Lichenologist, 9(2): 170-173.

(Köfaragó-)Gyelnik, V. (1931) Additamenta ad cognitionem Parmeliarum I et II. Feddes Repertorium Specierum Novarum Regni Vegetabilis, 29: 389-397; 401-419.

——————— (1935) Revisio typorum ab auctoribus variis descriptorum I. Annales Musei Nationalis Hungarici, (Evkonyv Orszagos Magyar Termeszettundomanyi Museum), 29: 1-54.

——————— (1936) Revisio typorum ab auctoriubus variis descriptorum II. Annales Musei Nationalis Hungarici, (Evkonyv Orszagos Magyar Termeszettundomanyi Museum), Pars Botanica, 30: 119-135.

——————— (1938a) Additamenta ad cognitionem Parmeliarum VIII. Sydowia Annales Mycologici, 36(4): 267-294.

——————— (1938b) Revisio typorum ad auctoribus variis descriptorum III. Annales Musei Nationalis Hungarici, (Evkonyv Orszagos Magyar Termeszettudomanyi Museum), Pars Botanica, 31: 2-57.

Hale, M.E. (1964) The *Parmelia conspersa* group in North America and Europe. The Bryologist, 67: 462-473.

——— (1965) A monograph of *Parmelia* subgenus *Amphigymnia*. Contributions from the United States National Herbarium, 36(5): 191-358.

——— (1967a) New taxa in *Cetraria*, *Parmelia* and *Parmeliopsis*. The Bryologist, 70: 414-422.

——— (1967b) The Biology of the lichens. Edward Arnold, London. viii + 176 pp.

——— (1968) A synopsis of the lichen genus *Pseudevernia*. The Bryologist, 71(1): 1-11.

——— (1969) How to Know the Lichens. W.C. Brown, Dubuque, Iowa. vii + 226 pp.

——— (1971) Studies on *Parmelia* subgenus *Xanthoparmelia* (Lichenes) in South Africa. Botaniska Notiser, 124: 343-354.

——— (1973) Fine structure of the cortex in the lichen family Parmeliaceae viewed with the scanning electron microscope. Smithsonian Contributions to Botany (10).

——— (1974a) New combinations in the lichen genus *Pseudoparmelia* Lynge. Phytologia, 28: 188-191.

——— (1974b) New combinations in the lichen genus *Parmotrema* Massalongo. Phytologia, 28. 334-339.

——— (1974c) Delimitation of the lichen genus *Hypotrachyna* (Vainio) Hale. Phytologia, 28: 340-342.

Hale, M.E. (1974d) *Bulbothrix*, *Parmelina*, *Relicina* and *Xanthoparmelia*, four new genera in the Parmeliaceae (Lichenes). Phytologia, 28(5): 479-490.

—————— (1974e) The Biology of the Lichens. Edward Arnold, London. (2nd Ed). viii + 181 pp.

—————— (1976a) A monograph of the lichen genus *Pseudoparmelia* Lynge (Parmeliaceae). Smithsonian Contributions to Botany, (31).

—————— (1976b) Synopsis of a new lichen genus *Everniastrum* Hale (Parmeliaceae). Mycotaxon, 3(3): 345-353.

—————— *(1976c) Lichen structure viewed with the scanning electron* microscope. pp. 1-15, in: Brown, D.H., Hawksworth, D.L. and Baily, R.H. (Eds.) Lichenology: Progress and Problems. Academic Press, London - New York - San Francisco. xii + 551 pp.

—————— (1979) How to know the lichens (Ed. 2) W.C. Brown, Dubuque, Iowa. viii + 246 pp.

Hale, M.E. and Kurokawa, S. (1964) Studies on *Parmelia* subgenus *Parmelia*. Contributions from the United States National Herbarium, 36: 121-191.

Harris, G.P. (1976) Water content and productivity of lichens. pp. 452-468, in: Lange, O.L., Kappen, L. and Schulze, E-D. (Eds). Water and Plant Life.Problems and Modern Approaches. Springer-Verlag, Berlin - Heidelberg - New York. xx + 536 pp.

Haslam, E. (1974) The Shikimate Pathway. Butterworths, London. x + 316 pp.

Hawksworth, D.L. (1976) Lichen chemotaxonomy, pp. 139-184, in: Brown, D.H., Hawksworth, D.L. and Bailey, R.H. (Eds.) Lichenology: Progress and Problems. Academic Press, London - New York - San Francisco. xii + 551 pp.

———————— (1978) The Taxonomy of the Lichen-forming Fungi: reflections on some fundamental problems. pp. 211-243 in: Street, H.E. (1978) Essays in Plant Taxonomy. Academic Press, London - New York - San Francisco. xiii + 304 pp (p.228).

Hayaishi, O. (1974) Molecular Mechanism of Oxygen Activation. Academic Press, New York.

Hendrickson, J.B., Ramsay, M.V.J. and Kelly, T.R. (1972) A new synthesis of depsidones diploicin and gangaleoidin. Journal of the American Chemical Society, 94: 6834-6843.

Hiller, N. and Dunlevey, J.N. (1978) The Bokkeveld-Witteberg boundary in the Montaque-Touws River area, Cape Province. Transactions of the geological Society of South Africa, 81: 101-104.

Hoffmann, G.F. (1790) Descriptio et Adumbratio Plantarum e Classe Cryptogamica Linnaei quae Lichenes dicuntur. v. 1 Lipsiae.

Holmgren, P.K. and Keuken, W. (1974) Index Herbariorum, Part 1. The Herbaria of the World. Oosthoek, Scheltema en Holkema, Utrecht Ed. 6. 397 pp.

Honegger, R. (1978) The ascus apex in lichenised fungi 1. The *Lecanora*-, *Peltigera*- and *Teloschistes* types. The Lichenologist, 10(1): 47-67.

Hooker, J.D. and Taylor, T. (1844) Lichenes Antarctici. Hooker's Journal of Botany, 3: 634-658.

Hue, A.M. (1890) Lichenes exoticos a proffesore W. Nylander descriptos vel recognitos. Nouvelles Archives du Muséum Paris (3) 2: 209-322.

——————— (1899) Lichenes extra-Europaei a pluribus collectoribus ad Museum Parisiense missi. Nouvelles Archives du Muséum Paris (4) 1: 1-250.

Huneck, S. and Follman, G. (1971) Mitteilungen über Flechteninhaltsstoffe LXXXVII. Neue Flechtenanalysen. Willdenowia, 6: 273-282.

Iskandar, I.K. and Syers, J.K. (197[illegible]) Solubility of lichen compounds in water : pedogenic implications. The Lichenologist, 5: 45-50.

————————————————— (1972) Metal-complex formation by lichen compounds. Journal of Soil Science, 23: 255-265.

Jack, A.M. (1979) Metamorphic variations across western Namaqualand. Annual Report of the Precambrian Research Unit, University of Cape Town, 16: 35-46.

Jahns, H.M. (1973) Anatomy, morphology and Development. pp. 3-58, in: Ahmadjian, V. and Hale, M.E. (Eds.) The Lichens. Academic Press, New York - London. xiv + 697 pp.

James, P.W., Hawksworth, D.L. and Rose, F. (1977) Lichen Communities in the British Isles: A Preliminary Conspectus. pp. 295-413 in: Seaward, M.R.D. (Ed.) Lichen Ecology. Academic Press. London - New York - San Francisco. x + 550 pp.

Jatta, A. (1902) Licheni Cinesi raccolti allo Shen-Si Negli anni 1894-1898, dal rev. Padre Missionario G. Giraldi. Nuovo Giornale Botanico Italiano (Nuova serie) 9: 460-481.

Joubert, P. (1971) The regional tectonism of the gneisses of part of Namaqualand. Bulletin of the Precambrian Research Unit, University of Cape Town, 10: 1-220.

Kappen, L. (1973) Response to extreme environments, pp. 311-380, in Ahmadjian, V. and Hale, M.E. (eds.) The Lichens. Academic Press, New York - London. xiv + 697 pp.

Karnefelt, I. (1979) The brown fruticose species of *Cetraria*. Opera Botanica (46): 1-150.

Keogh, M.F. (1976) 2'-O-demethylpsoromic acid from *Usnea* sp. Phytochemistry, 15, 1801.

Holmgren, P.K. and Keuken, W. (1974) Index Herbariorum, Part 1. The Herbaria of the World. Oosthoek, Scheltema en Holkema, Utrecht Ed. 6. 397 pp.

Honegger, R. (1978) The ascus apex in lichenised fungi 1. The *Lecanora-*, *Peltigera-* and *Teloschistes* types. The Lichenologist, 10(1): 47-67

Hooker, J.D. [illegible] or. T. (1844) Lichenes Antarctici. Hooker's Journal [illegible] 634-658.

Hue, A.M. [illegible] exoticos a proffesore W. Nylander descriptos vel [illegible] Nouvelles Archives du Muséum Paris (3) 2: 20[illegible]-322.

— ——— (1899) Lichenes extra-Europaei a pluribus collectoribus ad Museum Parisiense missi. Nouvelles Archives du Muséum Paris (4) 1: 1-250.

Huneck, S. and Follman, G. (1971) Mitteilungen über Flechteninhaltsstoffe LXXXVII. Neue Flechtenanalysen. Willdenowia, 6: 273-282.

Iskandar, I.K. and Syers, J.K. (1971) Solubility of lichen compounds in water : pedogenic implications. The Lichenologist, 5: 45-50.

——————— ——————————— (1972) Metal-complex formation by lichen compounds. Journal of Soil Science, 23: 255-265.

Jack, A.M. (1979) Metamorphic variations across western Namaqualand. Annual Report of the Precambrian Research Unit, University of Cape Town, 16: 35-46.

Jahns, H.M. (1973) Anatomy, morphology and Development. pp. 3-58, in: Ahmadjian, V. and Hale, M.E. (Eds.) The Lichens. Academic Press, New York - London. xiv + 697 pp.

James, P.W., Hawksworth, D.L. and Rose, F. (1977) Lichen Communities in the British Isles: A Preliminary Conspectus. pp. 295-413 in: Seaward, M.R.D. (Ed.) Lichen Ecology. Academic Press. London - New York - San Francisco. x + 550 pp.

Jatta. A. (1902) Licheni Cinesi raccolti allo Shen-Si Negli anni 1894-1898, dal rev. Padre Missionario G. Giraldi. Nuovo Giornale Botanico Italiano (Nuova serie) 9: 460-481.

Joubert, P. (1971) The regional tectonism of the gneisses of part of Namaqualand. Bulletin of the Precambrian Research Unit, University of Cape Town, 10: 1-220.

Kappen, L. (1973) Response to extreme environments, pp. 311-380, in Ahmadjian, V. and Hale, M.E. (eds.) The Lichens. Academic Press, New York - London. xiv + 697 pp.

Karnefelt, I. (1979) The brown fruticose species of *Cetraria*. Opera Botanica (46): 1-150.

Keogh, M.F. (1976) 2'-0-demethylpsoromic acid from *Usnea* sp. Phytochemistry, 15, 1801.

Keogh, M.F. (1978) New β-orcinol depsidones from *Xanthoparmelia quintaria* and a *Thelotrema* sp. Phytochemistry, 17(7): 1192-1193.

Keyser, A.W. (1973) A preliminary study of the type area of the *Cistecephalus* zone of the Beaufort series, *and a revision of* the Anomodont family Cistecephalidae. Memoirs of the Geological Survey of South Africa, 62.

Keyser, A.W. and Smith, R.M.H. (1979) Vertebrate biozonation of the Beaufort group with special reference to the Western Karoo Basin. Annals of the Geological Survey of South Africa, 12: 1-36.

Keyser, A.W., Theron, J.N. and Jonnson, M.R. (1979) Note on the Ecca-Beaufort boundary in the western Karoo. Annals of the Geological Survey of South Africa, 12: 69-72.

Kitching, J.W. (1979) The stratigraphic distribution and occurrence of South African fossil amphibia. Palaeontologia Africana, 21: 101-112.

Knapp, R. (1973) Die Vegetation von Afrika. G. Fischer Verlag. Stuttgart.

Korf, R.P. (1973) Discomycetes and Tuberales, pp. 249-319, in: Ainsworth, G.C., Sparrow, F.K. and Sussman, A.S. (Eds.) The Fungi, v. IV A. Academic Press. New York - San Francisco - London. xviii + 621 pp.

Krog, H. (1978) On *Parmelia protomatrae (Xanthoparmelia)*, an overlooked lichen species in Europe. Norwagian Journal of Botany, 25(1): 51-54.

Krog, H. and Swinscow, T.D.V. (1979) *Parmelia* subgenus *Hypotrachyna* in East Africa. Norwegian Journal of Botany, 26(1): 11-43.

Kröner, A. and Blignaut, H.H. (1976) Towards a definition of some tectonic and igneous provinces in western South Africa and southern South West Africa. Transactions of the geological Society of South Africa, 79: 232-238.

Kurokawa, S. (1967) On the occurrence of diffractaic, physodalic and psoromic acid in the Parmeliae. Bulletin of the National *Science Museum* [Kokuritsu Kagaku Hakubutsukan, Kenkyu Hokoku] (Tokyo), 10(3): 369-378.

———————— (1969) On the occurrence of Norlobaridone in Parmeliae. Journal of the Hattori Botanical Laboratory [Hattori Shokubutsu Kenkyujo] (32): 205-218.

Kurokawa, S. and Elix, J.A. (1971) Two new Australian Parmeliae. Journal of Japanese Botany, 46(4): 113-116.

Kurokawa, S., Elix, J.A., Watson, P.L. and Sargeant, M.V. *(1971) Parmelia novata* a new lichen species producing two new depsidones. Journal of Japanese Botany, 46(2): 33-36.

Kurokawa, S. and Filson, R.B. (1975) New species of *Parmelia* from South Australia. Bulletin of the National Science Museum [Kokuritsu Kagaku *Hakubutsukan, Kenkyu Hokoku*] *Series* B (Botany), 1(1): 35-48 + 4 plates.

Lange, O.L. Schulze, E-D. and Koch, W. (1970) Experimentell-ökologische Untersuchungen an Flechten der Negev - Wüste II. CO_2- Gaswechsel und Wasserhaushalt von *Ramalina maciformis* (Del.) Bory, am natürlichen Standort wärend der sommerlichen Trockenperiode. Flora (Jena), 159: 38-62.

Laundon, J.R. (1979) Deceased lichenologists: Their abbreviations and herbaria. The Lichenologist, 11(1): 1-26.

Lawrey, J.D. (1977) Adaptive significance of 4-O-methylated lichen depsides and depsidones. The Lichenologist, 9(2): 137-142.

Leistner, O.A. and Morris, J.W. (1976) Southern African place names. Annals of the Cape Provincial Museums, 12: 1-565.

Linnaeus, C. (1753) Species Plantarum. L. Salvii, Stockholm. xii + 1200 + 31 pp.

Lynge, B. (1937) Lichenes Africani novi ab E.A. Vainio recogniti. Revue Bryologique et Lichenologique, 10: 78-91.

Maass, W.S.G., McInnes, A.G., Smith, D.G. and Taylor, A. (1977) Lichen substances X. Physciosporin, a new chlorinated depsidone. Canadian Journal of Chemistry, 55: 2839-2844.

MacFarlane, J.D. and Kershaw, K.A. (1978) Thermal sensitivity in lichens. Science, 201 (4357): 739-741.

Magnusson, A.H. (1929) A monograph of the genus *Acarospora*. Kungliga Svenska Vetenskapsakademiens Handlingar, (3) 7(4): 1-400.

——————— (1932) Lichens from western North America mainly Washington and Alaska. Annales de Cryptogamie Exotique, 5: 16-38.

——————— (1933) Supplement to the monograph of the genus *Acarospora*. Annales de Cryptogamie Exotique, 6(1): 13-48.

——————— (1956) A second supplement to the monograph of *Acarospora* with Keys. Göteborgs Kungliga Vetenskaps och Vitterhetssamhälles *Handligar* 6B *(17): 1-34.*

Magnusson, A.H. and Zahlbrückner, A. (1944) Hawaiian lichens II. The Families Lecideaceae to Parmeliaceae. Arkiv för Botanik, 31A(6): 1-109.

Mathey, A. (1971) Contribution a l'étude du genre *Siphula* (lichenes) en Afrique. Nova Hedwigia, 22: 795-878.

Meyer, H.H.J. (1890) Ostafrikanischen Gletscherfahrten. H. Keil. [English translation by: Calder, E.H.S. (1891) Across East African Glaciers; The First Ascent of Kilimanjaro. G. Philip & Son, London. xx + 404 pp. 8pls. 32 figs. 3 maps.]

Minks, A. (1900) Beiträge zur Erweiterung der Flechtengattung *Omphalodium*. Mémoires de l'Herbier Boissier, (21): 79-94.

Moberg, R. (1977) The Lichen genus *Physcia* and allied genera in Fennoscandia. Symbolae Botanicae Upsalienses, 22(1): 1-108.

Monteith, J.L. (1975) (Ed.) Vegetation and the Atmosphere. v. 1. Principles. Academic Press, London - New York - San Francisco. xx + 278 pp.

Moore, J.M (1977) The geology of the Namiesberg, northern Cape. Bulletin *of the Precambrian* Research Unit, University of Cape Town, 20.

Mosbach, K. (1964) On the biosynthesis of lichen substances. Part 1. The depside gyrophoric acid. Acta Chemica Scandinavica, 18: 329-334.

——————— (1973) Biosynthesis of lichen substances, pp. 523-546, in: Ahmadjian, V. and Hale, M.E. (Eds.) The Lichens. Academic Press, New York - London. xiv + 697 pp.

Mosbach, K. and Bävertoft, I. (1971) A comparative study on the biosynthesis of palmitic and orsellinic acids in *Penicillium baarnense*. *Acta Chemica Scandinavica 25: 1931-1936.*

Mosbach, K. and Ehrensvärd, U. (1966) Studies on lichen enzymes. Part 1. Preparation and properties of a depside hydrolysing esterase and of a orsellinic acid decarboxylase. Biochemical and Biophysical Research Communications, 22(2): 145-150.

Müller-Argau, J. (1883) Lichenologische Beiträge XVII, Flora, 66(2): 17-25; 45-48.

——————— (1888) Lichenologische Beiträge XXX, Flora, 71: 528-552.

——————— (1891) Lichenologische Beiträge XXXV, Flora, 74: 371-382.

Nash, T.H. (1973) Two new species of *Xanthoparmelia* from Arizona. The Bryologist, 76: 214-215.

——————— (1974a) Chemotaxonomy of Arizonan lichens of the genus *Parmelia* subgenus *Xanthoparmelia*. Bulletin of the Torrey *Botanical Club*, 101(6): 317-325

——————— (1974b) New and additional *Xanthoparmelia* from New Mexico. The *Bryologist*, 77: 72-73.

Nicollier, G., Rebetez, M. et Tabacchi, R. (1979) Identification et synthèse de nouveaux depsides isolés de la mousse de chêne (*Evernia prunastri* (L) Ach.). Helvetica Chimica Acta, 62(3): 711-717.

de Notaris, G. (1846) Frammenti lichenografici di un lavaro inedito. Giornale Botanico Italiano 1(1): 174-224.

——————— (1847) Nuovi caratteri di alcuni generi della tribu delle Parmeliaceae. Memorie delle R. Accademia delle scienze di Torino, (2) 10: 365-389. [1849]

Nylander, W. (1860) Synopsis Methodica Lichenum. v.1. Paris. 430 pp.

——————— *(1866a) Circa novum in studio* lichenum criterium chemicum. Flora, 49: 198-201.

——————— (1866b) Quaedem addenda ad nova criteria chemica in studio lichenum. Flora, 49: 233-234.

——————— (1867) Hypochlorite *of lime* and *hydrate of potash, two new* criteria in the study of lichens. Journal of the Linnean Society of London, Botany, 9: 358-365.

——————— (1869) Circa reactiones Parmeliarum adnotationes. Flora, 52: 289-293.

Ohta, Y., Higgins, D.J. and Ribbons, S.W. (1975) Metabolism of resorcinylic compounds by Bacteria. Purification and properties of orcinol hydroxylase from *Pseudomonas putida* 01. Journal of Biological Chemistry, 250: 3814-3825.

Poelt, J. (1972) Die taxonomische Behandlung von Arten paaren bei den Flechten. Botaniska Notiser, 125: 77-81.

Potgieter, D.J. (1972) (Ed.) Standard Encyclopedia of Southern Africa, v.6. NASOU Ltd., Cape Town. 660 pp.

Pretorius, D.A. (1974) The structural boundary between the Kaapvaal and Sonama crustal provinces. University of the Witwatersrand Economic Geology Research Unit, 88: 1-27.

Pryor, W.A. (1976) Free Radicals in Biology. Academic Press. New York - San Francisco - London. *2 vols.*

Reddy, P.V., Rao, P.S. and Subramanyam, S. (1978) Influence of some lichen substances on mitosis in *Allium cepa* root tips. Indian Journal of Experimental Biology, 16(9): 1019-1020.

Reid, D.L. (1977) Geochemistry of Precambrian igneous rock in the lower Orange river region. Bulletin of the Precambrian Research Unit, University of Cape Town, 22.vii + 397 pp.

Renner, B., Henssen, A. und Gerstner, E. (1978) Methylvirensat und 5-chlor methylvirensat aus Arten der Flechtengattung *Pseudocyphellaria*. Zeitschrift für Naturforschung, 33C(11/12): 826-830.

Richard, O.-J. (1877) Catalogue des Lichens des Deux-Sèvres. Niort.

Richardson, D.H.S. and Young, C.M. (1977) Lichens and vertebrates, pp. 121-144 in: Seaward, M.R.D. (Ed.) Lichen Ecology. Academic Press. London - New York - San Francisco. x + 550 pp.

Sala, T. and Sargent, M.V. (1978a) New metabolites of the lichen *Buellia canescens* (Dicks.) de Not. Novel pthalide catabolites of depsidones. Journal of the Chemical Society, Chemical Communications, 1978 (23): 1041-1042.

——————————— (1978b) Base catalysed and thermal rearrangements of grisadiendiones to depsidones. Journal of the Chemical Society Chemical Communications, 1978(23): 1043-1044.

Santesson, J. (1973) Identification and isolation of lichen substances, pp. 633-652, in: Ahmadjian, V. and Hale, M.E. (Eds.) The Lichens. Academic Press, New York - London. xiv + 697 pp.

Schreber, J. (1791) Caroli a Linné, Genera Plantarum, v.2. Francofurti ad Moenum. Ed 8. 872 pp.

Schulze, R.E. and McGee, O.S. (1978) Climatic indices and classifications in relation to the biogeography of southern Africa, pp. 19-52, in: Werger, M.J.A. (Ed.) Biogeography and Ecology of Southern Africa, v.1. W. Junk. The Hague.

Sheard, J.W. (1974) The genus *Dimelaena* in North America north of Mexico. The Bryologist, 77: 128-141.

Shone, R.W. (1978) Giant *Cruziana* from the Beaufort group. Transactions of the geological Society of South Africa, 81(3): 327-329.

Sondheimer, E. (1964) Chlorogenic acids and Related Depsides. The Botanical Review, 60: 667-712.

Sprengel, K. (1827) Systema Vegetabilium (Caroli Linnaei) v.4, no. 2, Ed. 16. Gottingae.

Steiner, M. (1955) Ein stabiles Diaminreagens für lichenologische Zwecke. Berichte der Deutsche botanische Gesellschaft, 68: 35-40.

Stirton, J. (1877) Additions to the lichen flora of South Africa. Transactions of the Glasgow Society of Field Naturalists, 5: 211-220.

——————— (1878) On certain lichens belonging to the genus *Parmelia*. The Scottish Naturalist, 4: 200-203; 252-254; 298-299.

Stizenberger, E. (1890) Lichenaea Africana. Bericht über die Thatigkeit der St. Gallischen naturwissenschaftlichen Gesellschaft wärend des Vereinsjahres 1888/89: 105-249.

Stowe, C. (1979) The Upington Geotraverse, national geodynamics project - 1979. Progress report and outline of macrostructures. Annual Report of the Precambrian Research Unit, University of Cape Town, 16: 20-34.

Stratten, T. (1971) Sub-Karoo Geology of the Karoo basin in South Africa. 2nd International Gondwana Symposium, IUGS South Africa 1970, Papers and Proceedings, pp. 209-211.

Sturelid, S. and Lundström, H. (1972) The influence of lichen extracts on *Vicia faba* and Chinese hampster cells. Experientia, 28(10): 1238-1239.

Swinscow, T.D.V. and Krog, H. (1978) The genus *Dirinaria* in East Africa. Norwegian Journal of Botany, 25(2): 157-168.

Syers, J.K. and Iskander, I.K. (1973) Pedogenic significance of Lichens. pp. 225-248, in: Ahmadjian, V. and Hale, M.E. (Eds.) The Lichens. Academic Press, New York - London. xiv + 697 pp.

Talbot, A.M. and Talbot, W.J. (1960) Atlas of the Union of South Africa. The Government Printer, Pretoria. lxiv + 177 pp.

Taylor, C.J. (1967) The Lichens of Ohio. Part 1. Foliose Lichens. Ohio Biological Survey, Biological Notes no. 3. The Ohio State University, Columbus, Ohio.

———————— (1968) The Lichens of Ohio. Part 2. Fruticose and Cladoniform Lichens. Ohio Biological Survey, Biological Notes no. 4. The Ohio State University, Columbus, Ohio.

Taylor, T. (1847) New lichens principally from the Herbarium of Sir William J. Hooker. London Journal of Botany, 6: 148-197.

Theron, J.N. (1971) A stratigraphical study of the Bokkeveld group (series) Papers and Proceedings of the 2nd International Gondwana Symposium, IUGS South Africa, 1970, pp. 197-204.

de Tournefort, J.P. (1694) Élémens de Botanique Paris

Trigonometrical Survey Office, The (a) South Africa, 1:250,000, Rainfall map-sheets. The Government Printer, Pretoria 1965-1966.

———————————————— The (b) South Africa, 1:50,000, Topocadastral sheets. The Government Printer, Pretoria.

Truswell, J.F. (1977) The Geological Evolution of South Africa. Purnell, Cape Town. 218pp.

Turner, W.B. (1971) Fungal Metabolites. Academic Press, London - New York. ix + 446 pp.

Uys, N.J. and Enslin, J.F. (1970) Geological Map of the Republic of South Africa, and the Kingdoms of Lesotho and Swaziland. 1:1,000,000. The Government Printer, Pretoria. 4 sheets.

Vainio, E.A. (1926) Lichenes Africani Novi. Annales Universitatis Fennicae Aboënsis [Turun Suomalaisen Yliopiston Julkaisuja], (Ser. A) 2(3): 1-33.

Vajner, V. (1974) The tectonic development of the Namaqua Mobile Belt and its foreland in parts of the Northern Cape. Bulletin of the Precambrian Research Unit, University of Cape Town, 14. 210 pp.

Vartia, K.O. (1973) Antibiotics in lichens, pp. 547-561, in: Ahmadjian, V. and Hale, M.E. (Eds.) The Lichens. Academic Press, New York - London. xiv + 697 pp.

Visser, J.N.J. and Loock, J.C. (1978) Water depth in the main Karoo basin, South Africa, during Ecca (Permian) sedimentation. Transactions of the geological Society of South Africa, 81: 185-191.

Visser, J.N.J., Loock, J.C., van der Merwe, J., Joubert, C.W., Potgieter, C.D., McLaren, C.H., Potgieter, G.J.A., van der Westhuizen, W.A., Nel, L. and Lemmer, W.M. (1979) The Dwyka formation and Ecca group, Karoo sequence, in the northern Karoo basin, Kimberley-Britstown area. Annals of the geological Survey of South Africa, 12: 143-176.

Vobis, G. [illegible] ies on the germination of lichen conidia. The [illegible]gist, 9(2): 131-136.

Wainio, E.A. (1890) Étude sur la classification naturelle et la morpholo[illegible] des lichens du Brésil. Acta Societas pro Fauna et Flora Fennica, (2)7: 3-256.

——————— (1899) Lichenes in Caucaso et in peninsula Taurica annis 1884-1885 ab H. Lojka et M. a Déchy collecti. Természetrajzi Füzetek, 22: 269-343.

Weather Bureau. (Department of transport.) Report on the Meteorological Data of the year 19—— (Annual Reports). The Government Printer, Pretoria.

Weber, W.A. (1968) A taxonomic revision of *Acarospora* subgenus *Xanthothallia*. The Lichenologist, 4: 16-31.

——————— (1977) Environmental modification and lichen taxonomy, pp. 9-29 in: Seaward, M.R.D. (Ed.) Lichen Ecology. Academic Press. London - New York - San Francisco. x + 550 pp.

Werger, M.J.A. (1978a) Biogeographical division of southern Africa, pp. 145-170 in: Werger, M.J.A. (Ed.) Biogeography and Ecology of Southern Africa v.1. W. Junk, The Hague xv + 659 pp.

——————— (1978b) The Karoo-Namib Region, pp. 231-299 in: Werger, M.J.A. (Ed.) Biogeography and Ecology of Southern Africa. v.1. W. Junk, The Hague. xv + 659 pp.

Wessels, D.C.J., Wessels, L.A. and Holzapfel, W.H. (1979) Preliminary Report on Lichen feeding Coleoptera Occurring on *Teloschistes capensis* in the Namib Desert, South West Africa. The Bryologist, 82(2): 270-273.

Wiggers, F.H. (1780) Primitiae Florae Holsaticae. Kiliae.

Winnem, B. (1975) *Parmelia* subgenus *Amphigymnia* in Ethiopia. Norwegian Journal of Botany, 22: 141-166.

Wirth, V. (1972) Die Silikatflechten-Gemeinschaften in ausser alpinen Zentraleuropa. Dissertationes Botanicae, 17: 1-306.

Yamazaki, M., Matsuo, M. and Shibata, S. (1965) Biosynthesis of lichen depsides lecanoric acid and atranorin. The Chemical and Pharmaceutical Bulletin [Nihon Yakugakkai] (Tokyo) 13: 1015-1017.

Yamazaki, M. and Shibata, S. (1966) Biosynthesis of lichen substances II. Participation of C_1- unit to the formation of β-orcinol type lichen depside. The Chemical and Pharmaceutical Bulletin [Nihon Yakugakkai] (Tokyo) 14: 96-97.

Zahlbrückner, A. (1926) Afrikanische Flechten (Lichenes) [in Engler, A., Beiträge zur Flora von Afrika. LII] Botanische Jahrbücher für Systematik, *Pflanzengeschichte und Pflanzengeographie,* 60: 468-564.

——————— (1929) Catalogus Lichenum Universalis, v.6. Borntraeger, Liepzig. 618 pp.

——————— (1932) Lichenes in Africa lecti. Annales de Cryptogamie Exotique, 5: 198-275.

Zopf, W. (1907) Die Flechtenstoffe in chemischer, botanischer, pharmakologischer und technischer Beziehung. Jena. xi + 450 pp.

———— (1908) Beiträge zu einer chemischen Monographie der Cladoniaceen. Berichte der Deutscha botanische Gesellschaft, 26: 51-113.

Zuckerkandl, E. (1968) The evolution of hemoglobin, pp. 53-61 in: Readings from Scientific American; Bio-organic Chemistry. Freeman and Co., San Francisco. 317 pp.

7 INDEX TO LIVING TAXA AT GENUS LEVEL OR LOWER

(Excluding Table 4)

7 INDEX TO LIVING TAXA AT GENUS LEVEL OR LOWER

(Excluding Table 4)

Index to taxa cont. Pages

Index to taxa cont. Pages

Index to taxa cont.

Index to taxa cont.

Index to taxa cont. Pages

Index to taxa cont. Pages

Index to taxa cont. Pages

Index to taxa cont. Pages

Index to taxa cont. Pages

Index to taxa cont. Pages

Index to taxa cont. Pages

Index to taxa cont. Pages

Index to taxa cont. Pages

Author Brusse Franklin Andrej
Name of thesis A Taxonomic And Geographic Study Of The Genus Xanthoparmelia In The Karoo. 1980

PUBLISHER:
University of the Witwatersrand, Johannesburg