A REVISION OF THE LICHEN GENUS SPHAEROPHORUS

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ABSTRACT

A REVISION OF THE LICHEN GENUS SPHAEROPHORUS

By

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This revision is an attempt at a worldwide monograph of the lichen genus Sphaerophorus, using several of the modern taxonomic research techniques. The study is based on the morphological, anatomical, and chemical study of over 3500 specimens from 16 herbaria and from personal fieldwork carried out in British Columbia and southern Chile and Argentina.

Scanning-electron microscope work was carried out on the surface, cortical, and medullary regions of several species, and the results and figures are presented.

Four lichen substances are reported for the first time from the genus, including protocetraric acid and norstictic acid. Unknown substances have been found in S. ramulifer and S. dodgei.

Four genera are placed in synonomy with Sphaerophorus including Bunodophoron, Thysanophoron, Pleurocybe, and Pseudosphaerophorus, and the genus Calycidium is excluded. The studies resulted in three new subgenera: Sphaerocarpus, Bunodophorus, and Aghimus. Three new combinations are made: S. patagonicus (Dodge) Ohls., S. kinabaluensis (Sato) Ohls., and Siphula complanata (Hook. f. et Tayl.)

Ohls. Twenty species of _Sphaerophorus_ are currently recognized and a key for their identification along with a description, nomenclatural remarks and discussion are included. Six species are described as new including: _S. coomerensis_, _S. dodgei_, _S. imshaugii_, _S. macrocarpus_, _S. microsporus_, and _S. murrayii_.

The distribution of the species are discussed along with the distribution of the various chemotypes within the various species.

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I would finally like to extend a special word of thanks to my wife, Karen, and to my children who have been so patient during the past few months, enabling me to complete this study. Their support is greatly appreciated.

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CHAPTER I

INTRODUCTION

"The genus Sphaerophoron, which derives its name from the spherical shape of the apothecia terminating the ramuli when in fructification, is one of the most beautiful and distinct of all the families of Lichens." This quotation from Turner (1839, p. 105) appropriately introduces one of the most unique but relatively little known and studied macrolichen genera.

Previous studies of Sphaerophorus, a lichenized fungus in the class Ascomycetes, have been for the most part regional floristic studies such as undertaken by Turner (1839) and Smith (1918) in Britain, Vainio (1927) in Finland, and Sato (1934, 1953) and Mituno (1938) in Japan. A study of Sphaerophorus by Murray (1960) in New Zealand is the most complete work in the genus in the southern hemisphere, but unfortunately some confusion in the taxonomy of the genus resulted when numerous infraspecific taxa were described.

Two of the more intéresting anatomical studies within the genus were published by Montagne (1841) and Schwendener (1860). In more recent years Lye (1969) completed a study on the distribution and ecology of S. melanocarpus and Rehm (1971) made a survey of the lichen substances from North American and European specimens of S. fragilis and S. globosus.

My study is an attempt at a worldwide monograph of the lichen genus Sphaerophorus using several of the modern taxonomic research techniques. The genus has a worldwide, generally oceanic distribution with the greatest species diversity concentrated in the southern hemisphere. My study included an examination of over 3500 specimens from various private and institutional herbaria throughout the world and from personal fieldwork carried out in British Columbia, southwestern Chile, and southern Argentina. Excellent and extensive collections by Dr. Henry A. Imshaug and Mr. Richard Harris have been seen from the Falkland Islands, Juan Fernandez, New Zealand, Auckland Islands, and Campbell Island. Areas which may be poorly represented in this study are tropical South America, Africa, China, and the Philippines.

The curators of the following herbaria are thanked for the loan of specimens. Dr. Teuvo Ahti (H, H-Nyl.), Mr. Peter James (BM), Dr. William Culberson (DUKE, Culberson), Dr. Irwin Brodo (CAN), Dr. Howard Crum (MICH), Dr. Mason HALE (US), Dr. P. Ponce de Leon (F), Dr. George Scott (OTA), Dr. Syo Kurokawa (TNS), Dr. B. Hamlin (WELT), Dr. I. M. Lamb (FH, FH-Tuck., FH-Tayl., FH-Sprag.), Dr. Henry Imshaug (MSC), Mr. Rex Filson (MEL), Dr. Carl-Fredrik Lundevall (S), Dr. S. Jovet-Ast (PC, PC-Hue), and to Dr. Carroll Dodge at the University of Vermont and Dr. G. Bratt of Tasmania for their private collections.

Methods

A survey of the literature was first undertaken to obtain the original descriptions of the taxa involved. At this time the nomenclatural status of each name was determined as well as the location of the type material. A xerox copy of the original publication of each species was made so all descriptions would be available for immediate reference. Each specimen studied was assigned a number and index cards prepared to facilitate retrival of such information as thallus morphology and anatomy, spore characters, medullary reactions, thin-layer chromatography results and label data.

CHAPTER II

HISTORICAL BACKGROUND

Linnaeus (1753) in his "Species Plantarum" placed all lichenized fungi within the genus *Lichen*, including one species, *Lichen fragilis*, now treated within the genus *Sphaerophorus*. Between 1753 and 1794 two more species now included within *Sphaerophorus* were described, *Lichen globosus* (Hudson, 1762) and *Lichen melanocarpus* (Swartz, 1788). In 1790 Necker proposed the unitary designation *Syrigosis* which may be rejected as a published generic name according to Art. 20(2) (Stafleu, 1972). In any case, *Sphaerophorus* Persoon (1794a) has been conserved against *Syrigosis* Neck. (1790) (see Lanjouw, 1956).

In 1793 Humboldt included *Lichen fragilis* L. in *Verrucaria* Wigg. (1780). Hoffmann in 1794 included *Lichen fragile* L. and *Lichen globiferum* L. within *Coralloides* Hoffm. non Wolf 1776, but as the genus when originally described by Hoffmann (1790) contained only one species, *Lichen paschale* (*Stereocaulon paschale*) that species would automatically become the type of *Coralloides* Hoffm. Hoffmann (1795) subsequently included *Lichen fragile* and *L. globiferum* in *Stereocaulon*. Persoon (1794a) included two species in his description of the genus *Sphaerophorus*, *S. fragilis* and *S. coralloides* (≡*Lichen globiferus*) with the latter name generally treated as a synonym of *Lichen globosus* Huds. Subsequently, Persoon (1794b) changed the spelling of *Sphaerophorus* to *Sphaerophorum* making it neuter, a gender which he believed would be more acceptable. Increasing the confusion in orthography, Acharius (1803) changed the genus name to Sphaerophoron, replacing the latin neuter ending with a Greek neuter ending. Since the genus was first validly published as Sphaerophorus, this is the name that must be used (Art. 73; Stafleu, 1972).

In his original description of Thamnium, Ventenat (1799) cited several figures from Plates 16 and 17 in Dillenius (1741). Included within these figures, according to Crombie (1880), are species classified today within the genera, Cladina, Cladonia, Sphaerophorus, and Roccella. Although James and Hawksworth (in Ainsworth, 1971) cite Sphaerophorus as one of the possible synonyms of Thamnium, Ventenat cites only two species in his description, Lichen rangiferina and L. roccella. Since Sphaerophorus is referred to only as a figure in the original publication it should be eliminated as a possible selection in the typification of Thamnium. The only species formally transferred to Thamnium is Thamnium roccella (Jaume Saint-Hilare, 1805). In any case, Thamnium Vent. has been rejected in the conservation of Thamnea Solander ex S. T. Brangniart.

Taxa formerly included in Sphaerophorus Pers. are Lecanora fruticulosa Eversm. (as Sphaerophorus gelatinosus Treviranus, 1816) and Siphula ceratites (Wahlenb.) Fr. (as Sphaerophorus ceratites Sprengel, 1827). See also under species excluded at end of taxonomic section (p. 191).

Recognizing a consistent and distinct morphology among certain species within Sphaerophorus, Massalongo (1861) proposed the genus Bunodophoron for those species with a compressed thallus. He included within this genus S. australe, S. compressum, and S. insigne, although the only new combination made was Bunodophoron australe.

Several closely related monotypic genera have been proposed for species usually included within Sphaerophorus. Stirton (1883b) described the genus Thysanophoron, considering the presence of cephalodia sufficient to exclude S. stereocauloides from the genus Sphaerophorus. Müller (1884) described Pleurocybe from Madagascar on the concept that no other species of Sphaerophorus had laminal apothecia or a medullary cavity. Laminal apothecia and erroneous spores observations led Sato (1967) to describe Pseudosphaerophorus based on material from Borneo. In my opinion these three genera should be included in Sphaerophorus and are in this study.

Dufourea flabellata described by Hue (1899) has been found to be a sterile and enlarged form of S. melanocarpus.

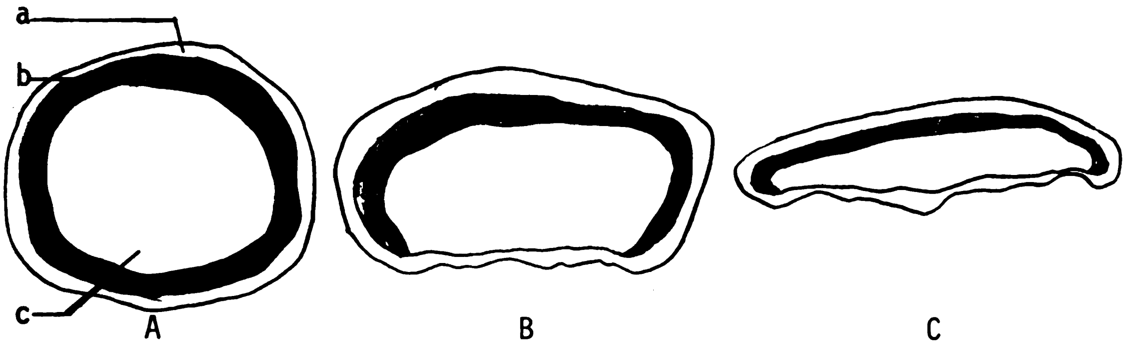
Subgeneric classification within the genus Sphaerophorus has been proposed only by Räsänen (1943) who introduced section Compressi and Teretes, but as he failed to provide the required latin diagnoses, these names are invalid. In another publication of the same year Räsänen (1943a) supplied a latin diagnosis for section Teretes, but since S. globiferus has been conserved as the type of the genus, section Teretes is synonomus with section Sphaerophorus.

Murray (1960) believed Calycidium cuneatum should be included in Sphaerophorus due to its broadly flattened branches which superficially resemble some species of Sphaerophorus. I feel, however, that as Calycidium differs in apothecial morphology, ascus and spore morphology, hyphal arrangement and several other key characters, it should be considered a distinct genus.

CHAPTER III

MORPHOLOGY

Sphaerophorus has a very plastic morphology but the species can be divided into three basic groups, terete, subterete to narrowly compressed, or distinctly flattened (see Table 1 and Text Figure 1).



Text Figure 1. Three major thallus types of *Sphaerophorus*. A. terete; B. compressed; C. broadly flattened. (a. cortex b. algal layer c. medulla)

The branches are generally dimorphic with the fertile branches infrequently branched and larger than the shorter sterile branches. Exceptions to this are *Sphaerophorus stereocauloides*, *S. diplotypus*, and *S. madagascareus* where sterile branches are similar in morphology to the fertile ones.

Methods

The general morphological characters were observed under a binocular microscope at 12X magnification noting the various features such as thallus shape, branching pattern, coralloid or isidioid structures and whether or not it was fertile. Any unusual or abnormal structures were also indicated. Anatomical features including spore size, shape and color, cortex and medullary hyphal arrangement and size were observed under oil at 1000X magnification.

Cortex

The development of the cortex is largely dependent on the shape of the thallus, producing a continuous gelatinous perimeter of equal thickness in the terete species, and in the flattened species forming a decidedly thicker upper cortex layer and a thinner lower layer. The thickness of the cortex depends somewhat on the region from where the section was taken, with the cortex being thicker near the base and becoming thinner near the apex.

The cortex is composed of fused thick-walled gelatinous hyphae intricated in various directions. The lumina of the hyphae are small 1.0-1.8 μ in diameter. Covering the cortex is a thin polysaccaride layer which may be similar to the epicortex layer described by Hale (1973) from *Parmelia*. The inner cortical layer adjacent to the algal layer is composed of individual hyphae diverging from the medullary layer, becoming gelatinized to form the cortical layer. The inner boundary of the cortical layer, next to the algal-medullary layer, has been used by Asahina (in Mituno, 1938) in separating *S. formosanus* from *S. melanocarpus*, the former having a uniform and the latter a zigzag appearance. After examining numerous collections it is my opinion that this character is so variable that it is of no taxonomic importance.

The upper surface of a thallus branch as viewed by SEM are provided for the following species: S. meiophorus, Figure 25; S. diplotypus, Figure 27; S. melanocarpus, Figure 30; S. patagonicus, Figure 33; S. tener, Figure 36.

Algae

The algae are contained within a distinct band between the cortex and medullary layers. In those species which have terete branches the algae form an almost uninterrupted band inside the cortex. In those species that are narrowly compressed to broadly flattened the algal layer is found only beneath the upper cortex or as isolated segments on the lower side. The thickness of the algal layer is variable, being somewhat dependent upon exposure to light. The algae in all species of Sphaerophorus are protococcoid, appearing as single spherical cells varying in size from 6.5-12.0 μ in diameter. An SEM photograph of algae can be seen in Figure 29.

Medullary Layer

The medullary layer is composed of generally longitudinally arranged, colorless, thick-walled hyphae. The hyphae are occasionally branched and can be seen with the SEM to be surrounded by numerous crystals (see Figure 32). The hyphae range in size from 6-12 μ in diameter with a 1.0-1.5 μ lumen. Some differences in density of hyphae and amount of fusion between hyphae can be noticed during sectioning. Sphaerophorus meiophorus (Figure 26) and S. tener (Figure 37) can be seen to have a dense firm medulla, whereas in S. diplotypus (Figure 28) the medullary layer is fairly lax and easily sectioned. The medulla is hollow in two species, with a fairly large cavity produced in S. madagascareus and a somewhat smaller cavity in S. diplotypus. SEM photographs of XS and LS views are provided for several species including; S. meiophorus, Figure 26; S. diplotypus, Figures 28 and 29; S. melanocarpus, Figures 31 and 32; S. patagonicus, Figures 34 and 35; S. tener, Figures 37 and 38.

Isidia

Isidia are small finger-like or cylindrical corticate outgrowths occurring along the upper surface of the thallus which incorporate the algae and fungal hyphae of the thallus. They may be simple or branched. It is not known if isidia are genetically controlled, but seem to be as they behave as species-constant traits (Hale, 1967). The isidia function as vegetative propagules and are probably of some importance as absorptive devices acting to increase surface area.

In the genus Sphaerophorus isidia or isidioid ramuli are known from several species and have been reported in various ways, such as "phyllocladia" or "phyllocladioid branches" by Murray (1960) and Lamb (1955), "coralloid isidia" (Räsänen, 1939) or "fibrillis cylindricis" by Zahlbruckner (1938). The structures are variable within the genus, but are quite constant within the species, with simple cylindrical isidia in S. formosanus and S. microsporus. Structures which are considered as branched phyllocladial ramuli are present in S. ramulifer and S. stereocauloides and less frequently in S. globosus.

Cephalodia

The first report of cephalodia from the genus Sphaerophorus was by Nylander (1869) when he described S. stereocauloides. It is now known that S. stereocauloides is the only species in the genus containing these irregularly shaped structures. Cephalodia result when blue-green algae come in contact with the lichen thallus and become surrounded by the hyphae. Several other genera which produce cephalodia include Peltigera, Coccotrema, and Stereocaulon. Not all species within these genera produce cephalodia, but for those species in which they do occur they are, for the most part, constant features and are probably under some genetic control.

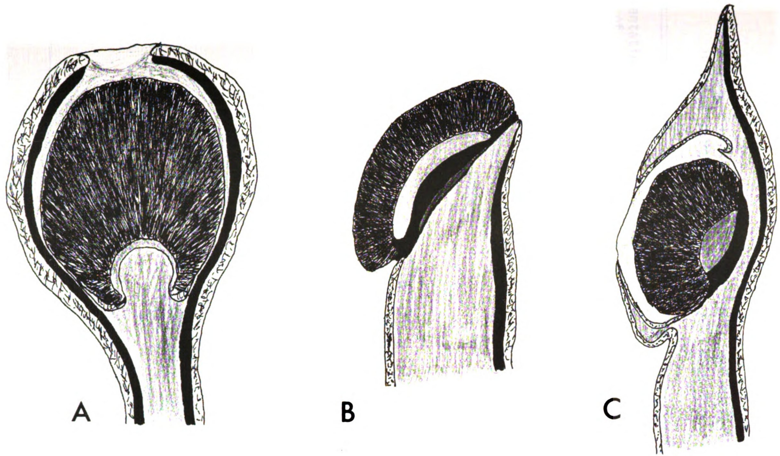
In S. stereocauloides the cephalodia vary in abundance from frequent to quite rare, usually occurring among the small phyllocladial ramuli along the primary branches. Their shape and size is also variable, usually forming small irregular cylindrical isidioid structures up to 5 mm in length by 1.5-4.0 mm in diameter. The cortex of the cephalodia is generally lighter in color than that of the thallus as the algae of the host plant are absent in the cephalodia. The blue-green Scytonema cells are contained near the apex within the cephalodia.

Millbank and Kershaw (1969) were able to demonstrate that the Nostoc colonies in the cephalodia of Peltigera aphthosa were able to fix nitrogen. The rate of nitrogen fixation was found to be under active metabolic control by the mycobiont, thus providing the host thallus with this basic element. It is possible a similar function may take place in the cephalodia of S. stereocauloides.

Apothecium

A characteristic common to all members of the Caliciales is the production of a mazaedium within the apothecium. The mazaedium is composed of sterile elements and spores freed from the asci which form a loose powdery mass. In *Sphaerophorus* the mazaedia develop within terminal or subterminal apothecia with the exception of *S. madagascareus*, where the ascocarps develop laminally along the lower surface of the branches (see Figure 14). Ascocarps may occasionally develop laminally in rare specimens of *S. microsporus* and *S. kinabaluensis*. The orientation of the mazaedium within the ascocarp is considered to be of some taxonomic importance and can be divided into three general groups (see Text Figure 2). In the subgenera *Sphaerophorus* and *Sphaerocarpus* the mazaedium is oriented apically becoming exposed as the enclosing receptacle ruptures along its apex. In the subgenus *Bunodophorus* the mazaedium occasionally seems to be oriented apically but is more often subapical to ventrally oriented. In subgenus *Aghimus* the mazaedium is typically ventrally oriented. These same three groups also have a fairly distinctive thallus morphology and are summarized in Table 1.

Other factors which are somewhat less important taxonomic characters are the shape and amount of exposure of the mazedia. For example, in *S. insignis* the surrounding receptacle maintains at least a partial covering over the mazaedium even in mature specimens (see Figure 8). In *S. murrayii* the mazaedium is well exposed and somewhat spherical or "ball-shaped."



Text Figure 2. Major types of apothecia and mazaedia orientation in Sphaerophorus. A. Subgenus Sphaerophorus; B. Subgenus Bunodophorus; C. Subgenus Aghimus.

TABLE 1. A summary of the mazaedia orientation and thallus morphology in Sphaerophorus (ascocarp laminal*).

Orientation of Mazaedium	Terete	Subterete to flattened	Flattened to broadly flattened
Apical	globosus		
	fragilis		
	meiophorus		
	stereocauloides		
	tener		
Apical or subapical	ramulifer	ramulifer	
	formosanus	formosanus	
		melanocarpus	
		kinabaluensis	
		dodgei	
		diplotypus	
		microsporus	
		imshaugii	
		coomerensis	
Ventral		*madagascareus	insignis
			patagonicus
			murrayii
			macrocarpus
			scrobiculatus

Asci

The asci produced in the mazaedia are cylindrical, 40-65 X 4.5-8 μ, and characteristically disintegrate at an early stage in their development, liberating the partially mature spores into the hymenium. Each ascus contains 8 non-septate spores arranged in a single row. The ascus walls are generally thin and contain a reddish brown pigment which turns green in KOH.

Ascospores

The spores in Sphaerophorus are of considerable taxonomic value having characteristic size, color, and shape (see Table 2).

A carbonaceous material is usually associated with the outer spore wall layer and is often thick enough to completely obscure the spore (see Figure 23). As pointed out by DeBary (1887) the spores of Sphaerophorus generally increase in size after being freed from the ascus. This same increase in spore size has been observed in Texosporium santi-jacobi, another member of the Caliciales, by Tibell (1968). He suggests that as the walls of the paraphyses contain numerous glycogen bodies and have been seen to enclose spores, that the paraphyses may be functioning as nutritive cells for the spores.

Pycnidia

Pycnidia are commonly found in all species of Sphaerophorus although they vary somewhat in abundance and in some specimens may be entirely lacking. Pycnidia and microconidia (spermatia) have been reported from the genus principally in studies by Lindsay (1866) and

TABLE 2. A summary of spore size, shape and color in Sphaerophorus.

SPORE COLOR	SPORE SIZE Small 5-8 μ	Medium 8-12 μ	Large 12-16 μ	SPORE SHAPE
Blue to green		globosus fragilis meiophorus stereocauloides		Broadly ellipsoid
Gray to hyaline	dodgii diplotypus formosanus kinabaluensis madagascareus melanocarpus microsporus tener	ramulifer		Spherical
Brown		imshaugii macrocarpus coomerensis	insignis patagonicus murrayii scrobiculatus	Spherical

and Hue (1898). Although Hue and Lindsay as well as this author have found slight differences in size (1-2μ) between some species, it is not believed that these bodies have any taxonomic value. The microconidia have been found to be rod-shaped and 4.0-6.5 X 1.0-2.5 μ. According to Zahlbruckner (1926) the microconidia are endobasidial in origin, but I have found them to be exobasidial in all species from which microconidia have been studied.

CHAPTER IV

SEM STUDIES

Scanning-electron microscope (SEM) work was completed on several species of Sphaerophorus and Calycidium cuneatum. The samples were photographed by Dr. William MacAfee of the Michigan State University SEM laboratory using an AMR 900 (see Figures 22-23 and 25-38). The samples were prepared by soaking the specimens in distilled water for at least 15 minutes to soften the cortex which was found to fracture unevenly when sectioned in the dry condition. Longitudinal, cross-sectional, and surface views of the samples were prepared by free-hand section under 12X magnification. The sectioned specimens were placed on double stick tape which had previously been placed on a 10 mm coverslip. The samples were then allowed to air dry overnight as it was found that specimens with some remaining moisture tended to crack under high magnification in the SEM. A substance called "tube coat" was used to fasten the coverslip and samples to the SEM stub. The sections were coated with gold under vacuum, then removed and placed in the SEM. Photographs of the sections were taken at a magnification of 600X and of the spores at 10,000X.

The upper surface of the sections were generally similar in structure and without diagnostic value within the genus (see Figures 25, 27, 30, 33 and 36). The hyphal orientation and degree of fusion among hyphae were of interest and could be of some value in distinguishing between several species such as S. meiophorus which had a relatively dense medulla with mostly fused hyphae (see Figure 26) and S. melanocarpus where the medulla was more lax and the hyphae were generally free from each other (see Figure 31). Further studies such as that completed by Hale (1973) are needed to fully evaluate the significance of SEM work in lichens.

CHAPTER V

INTRODUCTION TO CHEMICAL SUBSTANCES

The use of chemical tests in the taxonomy of lichens was first presented by Nylander (1866a) who utilized a potassium hydroxide solution (KOH) to elicit a color reaction in the medulla. In a second paper, Nylander (1866b) introduced the use of bleaching powder, calcium hypochlorite, to elicit additional color reactions. It was with the introduction of these two papers by Nylander that the controversy over the taxonomic value of chemical products began. Principally as a result of the careful and systematic work of Asahina and his students, who since 1933 have published on the chemical constituents of numerous species of lichens, it is now generally agreed that these unique substances are of considerable value in classifying lichens but disagreement occurs over the "weight" that should be assigned to the chemical variants (Culberson, 1964; Lamb, 1951). Some lichen taxonomists would like to describe new species for each chemical variant, whereas others more conservatively list them as chemical strains within a species. As this is a matter of personal philosophy, the rank assigned to a particular variant will never be entirely resolved until a knowledge of the biosynthetic pathways involved in the production of the medullary substances and the genetics involved in the pathways are found. I suspect even then the "weight" applied to the chemical vicariads will still be subject to discussion.

In this study a chemotype as proposed by Santesson (1968) will be used to indicate those individuals of a population which are chemically distinct, but are morphologically similar. This will allow for chemical variation within a species and will also indicate relationships among chemotypes, but will not burden the taxonomic literature with additional names. The concept of chemotypes is similar to ecotypes which are locally adapted populations of wide-ranging species that have optima and limits of tolerances adjusted to local conditions. This manifestation of having morphologically identical but chemically distinct populations occurs in several species of Sphaerophorus. As Odum (1971) suggests, organisms adapt themselves to the physical environment so as to reduce the limiting effects such as temperature, light, moisture and other physical conditions. It is likely that a particular chemotype, due to certain physiological requirements, will have a particular pattern of distribution as a result of its adaptation to the physical environment. This adaptation to a particular environment has led to a change in metabolic pathways and has manifested itself in the production of a particular lichen product. But as the exact biosynthetic pathway is not understood at the present time and as the extent of the genetic changes are not known, the evidence needed to erect new species for each chemotype is not sufficient.

Since Nylander's (1866a) first report, the use of lichen substances has played an increasing role in the taxonomy of lichens. Using modern microchemical techniques, as outlined by C. F. Culberson and Kristinsson (1970), C. F. Culberson (1972), Huneck (1968) and

J. Santesson (1967a), it is a relatively fast and efficient process to systematically test each specimen as it is being studied morphologically.

In the lichen genus Sphaerophorus, sphaerophorin and fragilin were the first substances to be reported (Zopf, 1898), although DeBary (1887) noted the presence of "granules of either colorless or only faint yellow color occurring in the inner cortex of Sphaerophoron coralloides." Stirton (1883a) had also realized the presence of a medullary substance in describing a new species, S. divergens Stirt., based on a KOH + yellow medullary reaction, now known to have resulted from the presence of thamnolic acid.

In the genus Sphaerophorus several species within a particular subgenus have been found to produce identical lichen substances. For example, within the subgenus Sphaerophorus, S. globosus, S. fragilis, and S. meiophorus all produce squamatic acid along with sphaerophorin. From this it would be reasonable to assume that the biosynthetic pathway involved in the production of the acid was present at an early time and has remained fairly constant as the species evolved morphologically (Rehm, 1971). Similarly within the subgenera Bunodophorus and Aghimus characteristic lichen substances are produced by the species of each subgenus with stictic acid, constictic acid and norstictic acid produced in the subgenus Bunodophorus and protocetraric acid produced in the subgenus Aghimus. Common to species of both subgenera is the production of sphaerophorin.

Methods

In the preliminary stages of this study a general survey was taken of the various species in the genus to determine which lichen substances might be expected. It was found that thin-layer chromatography could be used routinely to identify the substances, eliminating the need for microcrystal tests and "thalline" reactions.

Thin-layer chromatography was accomplished by removing a small section of thallus, placing it in a small culture tube, and extracting the substances from the thallus in 2-3 drops of acetone. The extracted lichen substances and known standards were then spotted with a micropipette onto Eastman thin-layer sheets (No. 6060, with fluorescent indicator). Using thin-layer sheets that had been cut in half (20 X 10 cm), twenty spots could be run simultaneously.

To determine what solvent would be used in the routine identification of lichen substances, several solvent systems were tried in a preliminary survey, including hexane-ethyl ether-formic acid (5:4:1), toluene-butyric acid (19:1), toluene-acetic acid (9:1), and benzene-dioxane-glacial acetic acid (90:25:4). The latter solvent was selected for routine use, as all substances were found to separate well. Another solvent, benzene, was used in the identification of isousnic acid by rechromatogramming the substance against a known standard on a (0.5N) oxalic acid buffered thin-layer sheet. After development and drying, the chromatograms were placed under UV light (254 and 265 nm) and the various spots were outlined in pencil.

Various developing sprays were tried to find a suitable solution which would help identify the lichen substances. Steiner's Stable

PD (para-phenylenediamine) would develop most spots but benzedine was used to verify trace amounts of sphaerophorin and to distinguish between squamatic and hypothamnolic acids. The various colors were noted and the chromatograms were filed for later reference. Near the end of the study a 10% H_2SO_4 solution was found to produce good color reactions if the sheets were gently heated to 90° C until dry.

Substances Found in the Genus Sphaerophorus

Protocetraric acid.--(See Table 3). This β orcinol depsidone has not been previously reported from *Sphaerophorus*. It was found in all specimens chromatogrammed in four of the seven species within the subgenus *Aghimus* including *S. coomerensis*, *S. imshaugii*, *S. murrayii*, and *S. insignis*. In nearly a third of the specimens of *S. murrayii*, it was the only substance found, with sphaerophorin being absent or in amounts that could not be detected chromatographically. In the remaining three species in the subgenus, *S. macrocarpus*, *S. patagonicus*, and *S. scrobiculatus*, protocetraric acid could not be found. *S. microsporus*, placed within the subgenus *Bunodophorus*, also produces this depsidone.

For identification by microcrystallization see Asahina, 1952, Plate 3, Figures 4 and 5.

Thamnolic acid.--(See Table 3). This β orcinol meta-depside, recently reported from *Sphaerophorus* by Rehm (1971) is known from only one species, *S. globosus*. In this species thamnolic acid always occurs with sphaerophorin and is rarely found to accompany squamatic acid. Another closely related compound hypothamnolic acid does not occur with thamnolic acid but is found to substitute for the acid. Rehm (1971) suggests possible biosynthetic pathways and relationships among the three substances thamnolic, squamatic and hypothamnolic acids.

For identification by microcrystallization see Thomson, 1967, Figure 42.

Constictic acid.--(See Table 3). The chemical nature of this substance is as yet unclear, although W. L. Culberson and C. F. Culberson (1970) does list it as a β orcinol depsidone. It appears to be closely related to stictic acid and norstictic acid as they are frequently found to occur together. Constictic acid was first reported from *Sphaerophorus* by Asahina (1968) and is now known to occur in seven species; *S. melanocarpus*, *S. formosanus*, *S. diplotypus*, *S. madagascareus*, *S. ramulifer*, *S. kinabaluensis*, and rarely in *S. macrocarpus*.

For identification by microcrystallization see Asahina, 1968, Figure 2D.

"Coccotrema" unknown.--(See Table 3 and Figure 21). In material of *S. ramulifer* from Campbell Island, the Auckland Islands and from New Zealand this interesting compound was found to completely substitute for stictic and constictic acids. This same substitution phenomenon has been observed in *Coccotrema granulata* from New Zealand. When chromatogrammed and sprayed with 10% H_2SO_4 this substance turned a characteristic red color and if sprayed with PD became a pale yellow-orange. Characteristic plates with sharply cut ends are produced in G.A.o-T. An ultraviolet absorption spectrum was run on this compound in 95% ethanol with a bimodal spectrum and peak absorbancies at 220 mu and at 307 mu.

Hypothamnolic acid.--(See Table 3). One of the two β orcinol meta-depsides in the genus, it was only recently reported from *Sphaerophorus* by Rehm (1971). This substance is known in the genus from two species, *S. globosus* and *S. fragilis*. Culberson (1969) gives as a possible mechanism for the formation of a meta-depside, the rearrangement of a para-depside. Using this approach, hypothamnolic acid is probably produced from a biosynthetic pathway similar to the one which produces squamatic acid.

For identification by microcrystallization see Thomson, 1967, Figures 21 and 22.

Squamatic acid.--(See Table 3). This substance was first reported from the genus in *S. meiophorus* by Asahina (1934) and is the only known β orcinol para-depside in the genus. It occurs along with sphaerophorin in three species, *S. globosus*, *S. fragilis*, and *S. meiophorus*, all members of the subgenus *Sphaerophorus*. In occasional specimens of *S. globosus* and *S. fragilis*, squamatic acid occurs with or is found in place of hypothamnolic acid. Squamatic acid was found to be present in all specimens of *S. meiophorus*.

For identification by microcrystallization see Thomson, 1967, Figure 12.

"Scrobiculatus" unknown.--(See Table 3 and Figure 24). This unknown substance was previously reported by Sato (1968) from *S. scrobiculatus*. It occurs in this species in a rather high concentration with a 4.3% yield realized from an ether extraction of the thallus. This unknown substance usually occurs with two other unknown substances, one of which seems to be an anthraquinone, fluorescing bright bluish white under UV light. The "scrobiculatus" unknown substance is characterized by being UV-, KOH+ purple, KC+ reddish to purple. The KOH reaction is difficult to achieve on the medulla, but can be seen by extracting the thallus on filter paper and then applying the KOH and KC tests to the filter paper. Recrystallization of this substance in GE produces clear elongate plates.

Stictic acid.--(See Table 3). This β orcinol depsidone was reported from the genus for the first time by Asahina (1968). It has been found in seven species, including *S. melanocarpus*, *S. formosanus*, *S. diplotypus*, *S. madagascareus*, *S. ramulifer*, *S. kinabaluensis* and rarely in *S. macrocarpus*. It always occurs with sphaerophorin and is usually found concurrently with norstictic and constictic acid. W. L. Culberson and C. F. Culberson (1970) suggest the derivation of this substance from norstictic acid by O-methylation.

For identification by microcrystallization see Thomson, 1967, Figure 31.

Norstictic acid.--(See Table 3). This β orcinol depsidone is usually present in only trace amounts and has not been previously reported from *Sphaerophorus*. It occurs along with stictic and constictic acids in *S. melanocarpus*, *S. ramulifer*, *S. formosanus*, *S. diplotypus*, *S. madagascareus*, and *S. kinabaluensis*. It can usually be detected by a faint PD+ yellow spot, or more commonly it can be seen as a fluorescent yellowish spot just above stictic acid on the thin-layer chromatogram under UV light.

For identification by microcrystallization see Thomson, 1967, Figures 29, 40, and 54.

Sphaerophorin.--(See Table 3). An orcinol para-depside first reported from Sphaerophorus by Zopf (1898), this substance is still known only from this genus. All species of Sphaerophorus, except S. scrobiculatus, have been found to contain this substance. In occasional specimens of S. insignis and in over one third of the specimens of S. murrayii this substance could not be demonstrated by thin-layer chromatography. Sphaerophorin is an interesting substance in that it is only one of two known compounds able to combine an orsellinic acid unit with a unit having a longer side (C. F. Culberson, 1969). The other substance reported to have this arrangement is its depsidone counterpart, grayanic acid, which occurs in the genus Cladonia.

For identification by recrystallization see Asahina, 1938, Figures 50 and 51.

"Dodgei" unknown.--(See Table 3). This substance has been found in only one species, S. dodgei. It has similar Rf values to usnic acid in the three standard solvent systems of C. F. Culberson (1972), but when developed on a thin-layer sheet containing an oxalic acid buffer the Rf is much lower. I suspect this unknown substance may be a related usnic acid compound as it reacts similarly with developing sprays, and has similar Rf values. This substance is usually in small concentrations and crystals could not be produced.

Isousnic acid.--(See Table 3). This acid, recently reported from Sphaerophorus by Nuno (1968), has been found to occur in the genus in only one species, S. ramulifer. According to Nuno, S. ramulifer (as S. isousnica Sato) is the only known species of lichen to produce isousnic acid but no usnic acid. In all specimens of S. ramulifer examined for this study isousnic acid was present. This substance occasionally occurs with stictic, norstictic, and constictic acids, along with sphaerophorin, although usually it is found to occur only with sphaerophorin. In rare specimens, isousnic acid may occur by itself, with sphaerophorin probably being present, but in small quantities that cannot be determined by thin-layer chromatography. In over 60% of the specimens from Campbell Island, and in rare specimens from New Zealand, isousnic acid occurs with sphaerophorin and an unknown substance (see "Coccotrema" unknown).

For identification by recrystallization see Nuno, 1968, Figures 1 and 2.

Fragilin. First reported from *S. fragilis* and *S. globosus* (as *S. coralloides*) by Zopf (1898), this anthraquinone is of little taxonomic importance, occurring in several species in trace amounts.

Parietin. First reported in *Sphaerophorus* by Bohman (1969) and later confirmed by Santesson (1970), parietin is one of the two anthraquinones known from this genus. Santesson suggests a possible biogenetic relationship between parietin and the other anthraquinone, fragilin, by chlorination of parietin. This substance is probably of little taxonomic value and has not been studied in any detail in this work.

TABLE 3. TLC data for the lichen products found in Sphaerophorus.

	Rf value X 100[a]			Reactions				
	solvent A	solvent B	solvent C	PD	Benzidine	H_2SO_4	$FeCl_3$	UV
Protocetraric acid	8	32	15	orangish yellow	-	gray	purplish	-
Thamnolic acid	11	33	26	yellow	reddish brown	pale brown	purplish brown	-
Constictic acid	18	8	8	orange	light brown	orange	light brown	-
"Coccotrema" unknown	35	15	10-11	pale orange	-	red	purplish	-
Hypothamnolic acid	20	36	29	-	yellowish brown	greenish yellow	brown	-
Squamatic acid	26	40	41	-	yellowish	pale yellow	pale brown	+
"Scrobiculatus" unknown	56-58	58	65	-	-	pale yellow	pale gray	-
Stictic acid	59	18	38	pale orange	-	orange	pale gray-ish brown	-
Norstictic acid[b]	63	36	46	pale yellow	-	-	-	-
Sphaerophorin	73	65	71	-	orange red	pale violet to brown	brown	+

TABLE 3--Continued.

	Rf value X 100[a]				Reactions				
	solvent A	solvent B	solvent C		PD	Benzidine	H_2SO_4	$FeCl_3$	UV
"Dodgei" unknown	79	74	80	36[c]	-	-	pale yellow	pale brownish	-
Isousnic acid	83	72	83	78[c]	-	light gray brown	greenish yellow to brown	yellow to brown	-

a. Three standard solvent systems of C. F. Culberson and H. Kristinsson (1970).

b. Norstictic acid is present in trace amounts so the characteristic color reactions are not indicated.

c. Solvent system of benzene; run on a (0.5N) oxalic acid buffered thin-layer sheet.

(The lichen substances were run on Eastman thin-layer sheets No. 6060 with fluorescent indicator).

CHAPTER VI

NUMERICAL TAXONOMY

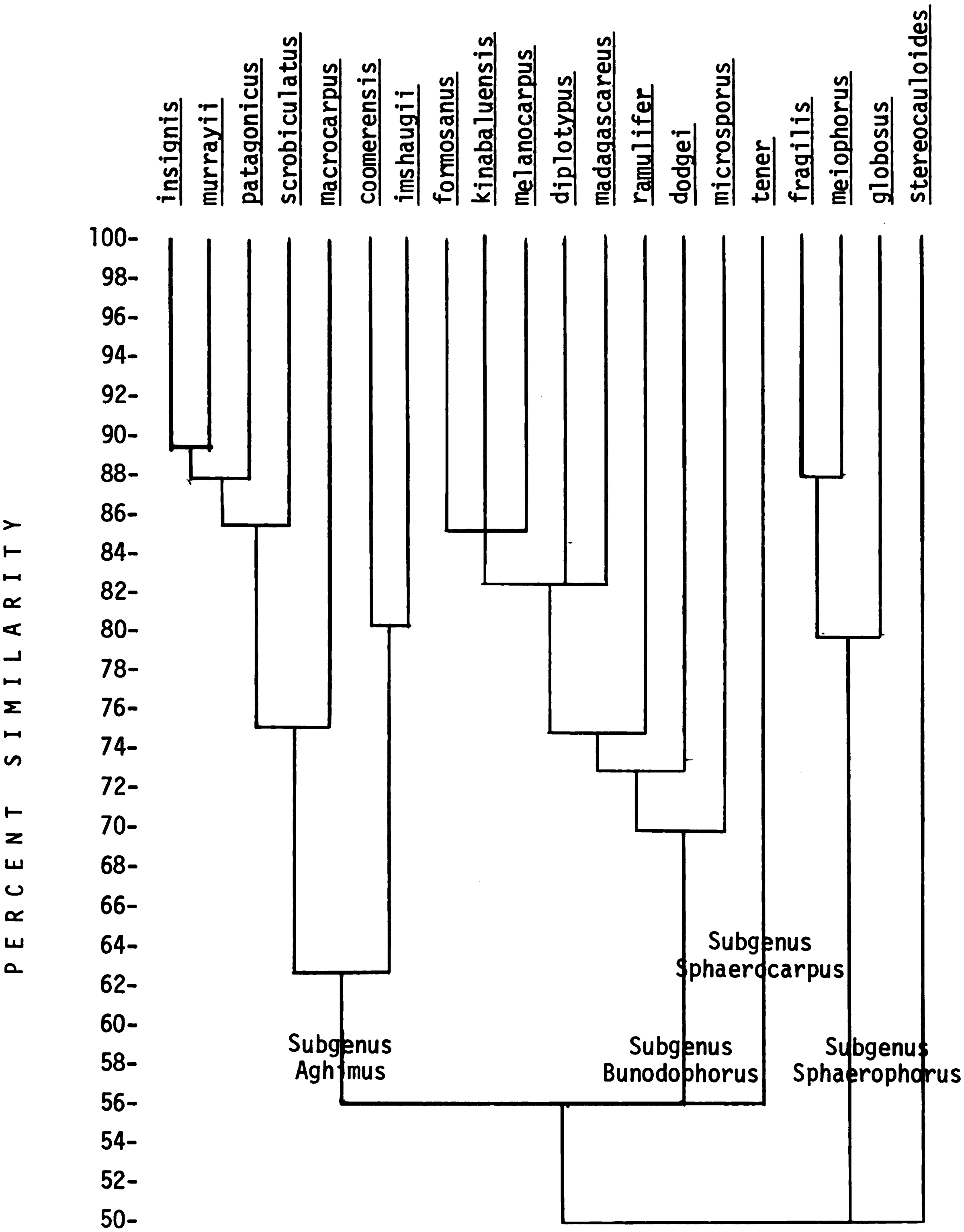
In an attempt to quantify and summarize somewhat objectively the characters used in the classification of the species in *Sphaerophorus*, a phenetic numerical taxonomic approach has been taken. It was thought that as the system of classification cannot truly show phylogenetic relationships because evolutionary data is lacking, it would be interesting to determine coefficients of similarity and perform a cluster analysis to group species with similar characters.

Although this approach has been widely used in bacteria (Lockhart, 1970) and in vascular plants (Davis and Heywood, 1963), to my knowledge, it has not been used in lichen taxonomy. The characters for analysis (as in Table 4) were selected from the key to the species and from the species descriptions. When two logically correlated characters were found, one of them was excluded to avoid excessive weighting of characters. The computation of the similarity index was done using the format presented in Lockhart (1970, p. 40). The similarity index (S) for each pair of organisms (a,b) was calculated as $S_{ab} = NS_{ab}/(NS_{ab} + ND_{ab})$, where NS stands for the number of characters common to both organisms, and ND stands for the number of unshared characters. Only those characters which were recorded as positive (+) contributed to NS; shared negative characters were not counted. Similar results, though not shown, were obtained when the similarity index (S) was calculated as $S_{ab} = NS_{ab}/N_{ab}$, where NS_{ab} is the number of characters, positive and negative, common to both species, and N_{ab} is the total number of characters recorded. A simple "single-linkage" procedure as outlined in Lockhart (pp. 51-52) was used to sort the species into groups. The results shown in Text Figure 3 help to objectively confirm the similarities among species assigned to the four subgenera.

TABLE 4. Characters and code used in classifying species of *Sphaerophorus*.

	coomerensis	diplotypus	dodgei	formosanus	fragilis	globosus	imshaugii	insignis	kinabaluensis	macrocarpus	madagascareus	meiophorus	melanocarpus	microsporus	murrayii	patagonicus	ramulifer	scrobiculatus	stereocauloides	tener
1. Branches solid	+	-	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+
2. Apothecia terminal	-	-	-	-	+	+	-	-	-	-	-	+	-	-	-	-	-	-	+	+
3. Apothecia laminal	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
4. Mazaedia oriented ventrally	-	-	-	-	-	-	-	+	-	+	-	-	-	-	+	+	-	+	-	-
5. Thallus branches terete	-	-	-	-	+	+	-	-	-	-	-	+	-	-	-	-	-	-	+	+
6. Thallus branch. broad. flat.	-	-	-	-	-	-	-	+	-	+	-	-	-	-	+	+	-	+	-	-
7. Medullary hyphae I+ blue	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-
8. Cortex isidiate	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
9. Cephalodia present	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-

10. Cortex thin (to 45 μ)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
11. Thallus caespitose	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+
12. Branches elong. & attenuate	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
13. Primary branch < 1.5 cm in length	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
14. Spores small, 5-8 μ in dia.	-	+	+	+	-	-	-	-	+	-	+	-	+	+	-	-	-	-	-	+
15. Spores large, 12-15 μ in dia.	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+	+	-	+	-	-
16. Spores broadly ellipsoid	-	-	-	-	+	+	-	-	-	-	-	+	-	-	-	-	-	-	+	-
17. Spores gray to hyaline	-	+	+	+	-	-	-	-	+	-	+	-	+	+	-	-	+	-	-	+
18. Spores brown	+	-	-	-	-	-	+	+	-	+	-	-	-	-	+	+	-	+	-	-
19. Mazaedium covered when mature	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
20. Containing protocetraric acid	+	-	-	-	-	-	+	+	-	-	-	-	-	+	+	-	-	-	-	-
21. Containing stictic & constictic	-	+	-	+	-	-	-	-	+	+	+	-	+	-	-	-	+	-	-	-
22. Containing isousnic acid	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
23. Containing squamatic acid	-	-	-	-	+	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-
24. Containing thamnolic acid	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25. Containing hypothamnolic acid	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26. Containing "Dodgei" unknown	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27. Containing sphaerophorin	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+



Text Figure 3. Phenetic dendrogram showing similarity of characters among species of Sphaerophorus.

CHAPTER VII

DISTRIBUTION

The genus Sphaerophorus has a worldwide oceanic distribution with fifteen of the twenty species occurring in the southern hemisphere. When looking at the distribution of the four subgenera of the genus three general patterns can be distinguished, each coinciding with a particular group within the genus (see Figure 39). The subgenus Sphaerophorus has principally a northern hemisphere circumboreal distribution, although S. globosus is a bipolar species occurring in extreme southern South America, the Falkland Islands, and as far south as the South Orkneys. Sphaerophorus stereocauloides, another member of this subgenus, is endemic to New Zealand. The most northern species, S. fragilis, has a high-arctic to arctic-alpine circumpolar distribution and is the only species that seems to be restricted to soil or rock.

The distribution of subgenus Bunodophorus is generally tropical to subtropical, except for S. ramulifer which occurs only in the southern hemisphere and S. melanocarpus, which occurs in tropical areas but is a widespread species ranging from Alaska and Norway to extreme southwestern Chile in areas of moderating temperatures and high rainfall. Endemics within this subgenus include S. dodgei known only from the Valdivian Region of Chile and Nahual Haupi National Park area of Argentina, S. madagascareus from Madagascar, and S. melanocarpus ssp. hawaiiensis from Hawaii.

The subgenera Sphaerocarpus and Aghimus have a southern hemisphere distribution with S. tener being the most common and widespread species occurring in southern South America, the Falkland Islands, New Zealand, Tasmania, Australia and several of the subantarctic islands including Auckland and Campbell Islands. Sphaerophorus murrayii is the only species of the subgenus Aghimus to extend into the northern hemisphere, occurring in Borneo and Hawaii, as well as in New Zealand and the Auckland Islands in the southern hemisphere. New Zealand with ten species of Sphaerophorus is the center of distribution for the southern hemisphere species. Summarized in Table 5 are the species found in several areas in the cool south temperate regions and the areas in which they occur.

TABLE 5. The species of *Sphaerophorus* occurring in the cool south temperate regions and their distribution. (* indicates endemic species).

	Argentina	Auckland Isl.	Australia	Campbell Isl.	Chile	Falkland Isl.	Juan Fernandez	New Zealand	Tasmania
*coomerensis**			X						
*dodgei**	X				X				
formosanus			X						
globosus	X				X	X			
imshaugii	X	X			X				
insignis	X	X	X	X	X			X	X
macrocarpus		X		X				X	X
melanocarpus	X	X	X	X	X	X	X	X	X
microsporus		X						X	
murrayii		X						X	X
patagonicus	X		X	X	X	X	X	X	X
ramulifer	X	X	X	X	X	X	X	X	X
scrobiculatus		X		X	X		X	X	X
*stereocauloides**								X	
tener	X	X	X	X	X	X	X	X	X

CHAPTER VIII

ECOLOGY

All species of the genus Sphaerophorus are known to have a generally oceanic distribution, preferring relatively moist and temperate conditions. In the tropics the plants grow at high altitudes where moisture is heaviest and the temperatures are cool. For example, in the mountains of Jamaica, S. melanocarpus occurs in areas generally receiving in excess of 3100 mm annual precipitation. Lye (1969) has additional information on the ecology of this species. Along the continents in the northern and southern hemisphere this genus is mainly coastal, but does range into the higher elevations of the coastal mountains, which again are areas that are high in precipitation (see pages 137-138 for additional comments).

With the exception of S. fragilis, which seems to be restricted to soil or rock, the genus is typically corticolous in the southern hemisphere, arctic North America, Japan and Europe. Sphaerophorus globosus does occur on soil or rock. In southern South America this species may form large patches up to one meter across on barren soil. At times these large patches of S. globosus grow along with S. tener, a lichen that is usually corticolous. Sphaerophorus ramulifer, S. melanocarpus, and S. scrobiculatus are also known to occur on rock or soil, but are more typically corticolous.

CHAPTER IX

FOSSIL LICHENS

Few authentic records of fossil lichens have been found although Göppert and Menge (1883) reported several specimens from Königsberg in deposits of Middle Miocene, including *S. globosus* (as *S. coralloides*).

CHAPTER X

TAXONOMY

The family Sphaerophoraceae was classified along with all lichens in the order Lecanorales according to Bessey (1950). Zahlbruckner (1926) placed the Sphaerophoraceae along with two other families producing mazaedia, the Caliciaceae and Cypheliaceae, into the subseries Coniocarpineae. The Coniocarpineae was classified in the series Gymnocarpeae which included all Discomycetes. Hale's (1967) recent taxonomic arrangement includes the Sphaerophoraceae, Caliciaceae, and Cypheliaceae in the order Caliciales, which is similar to Zahlbruckner's Coniocarpineae.

Family

The Sphaerophoraceae has generally included five genera classified together by their foliose or fruticose nature and by their development of a mazaedium. Choisy (1957) altered this slightly including only three genera, *Sphaerophorus* (*Thysanophoron*), *Acroscyphus*, and *Pleurocybe* within Sphaerophoraceae. *Tholurna* and *Calycidium* were excluded and placed within monogeneric families, Tholurnaceae and Calycidaceae. All three families were classified within the order Sphaerophorales.

It is my feeling that <u>Tholurna</u> and <u>Calycidium</u> should be placed within separate monotypic families and that <u>Acroscyphus</u> should also be excluded from the Sphaerophoraceae and placed within a separate family. There are sufficient major differences in thallus and apothecial morphology, spore characters, and lichen substances to establish monotypic families for <u>Calycidium</u>, <u>Acroscyphus</u>, and <u>Tholurna</u>. In this study <u>Pleurocybe</u> and <u>Thysanophoron</u> have been placed within the genus <u>Sphaerophorus</u>.

Genera closely related to <u>Sphaerophorus</u>

<u>Acroscyphus</u>.--Thallus composed of short fruticose branches, producing numerous erect globose apothecia along the lobes. Medulla characteristically orange in color due to the presence of calycin. Apothecia closed at first, mazaedium later becoming exposed through a small apical pore-like opening. Asci thin-walled, cylindric, containing 8 spores arranged in a single row. Spores uniseptate, deeply constricted in the middle, brown when mature, 22.0-30.0 X 12.5-14.0 μ.

<u>Tholurna</u>.--Thallus of horizontal squamulose lobes and erect subterete hollow, fertile branches, each containing a single apothecium. Apothecium opening early to expose the mazaedium which is surrounded by a paper-thin margin. Asci thin-walled, cylindric, containing 8 spores arranged in a single row. Spores uniseptate, deeply constricted in the middle, surrounded by a thickly ridged epispore, brown when mature, 16.0-20.0 X 8.0-10.0 μ.

Calycidium.--Thallus of broad, flattened, erect to decumbent foliose branches. One to several apothecia forming along the upper margin. Apothecia opening early to expose the mazaedium which is surrounded by a narrow thalline margin. Asci usually pyriform, thin-walled, containing 8 irregularly arranged spores. Spores nonseptate, spherical to irregularly ellipsoid, 4.5-6.5 μ in diameter. An SEM photograph of the hyphae of Calycidium cuneatum is provided in Figure 22.

SPHAEROPHORUS Pers.

Neue Annal. Bot. 1: 23. 1794 Nom. Cons. Lectotype: Sphaerophorus coralloides Pers. [≡ Lichen globiferus Linnaeus]

Bunodophoron Mass. Mem. Imp. Reale Ist. Veneto Sci. 10: 76. 1861. Holotype: Sphaerophoron australe Laur. (= Sphaerophorus melanocarpus (Sw.) DC.).

Thysanophoron Stirt. Trans. and Proc. Bot. Soc. Edinburgh 14: 359. 1883. Holotype: Thysanophoron pinkertonii Stirt. (= Sphaerophorus stereocauloides Nyl.).

Pleurocybe Müll. Arg. Flora 67: 613. 1884. Holotype: Pleurocybe hildebrandtii Müll. Arg. (= Sphaerophorus madagascareus Nyl.).

Pseudosphaerophorus Sato, Misc. Bryol. Lichenol 4: 108. 1967. Holotype: Pseudosphaerophorus kinabaluensis Sato (= Sphaerophorus kinabaluensis (Sato) Ohlsson).

Nomenclatural Remarks.--The genus Sphaerophorus Pers. has been conserved against Syrigosis Necker (1790) in Lanjouw (1965), but as Syrigosis was originally published as a unitary designation and not as a binomial, the name is invalid and can be rejected (Art. 20-2; Stafleu, 1972).

Lichen globiferus L., the type species of Sphaerophorus, requires typification, but as the original material was unavailable for study, it cannot be done at the present time. In the original description of Lichen globiferus, Linnaeus (1767) cites a specimen from Stenbrohult in southern Sweden collected by Linnaeus fil. Linnaeus also cites "Lichen fruticulosus coralloides non tubulosus cinereus ramosissimus, receptaculis sphaericis concoloribus," Mich. Gen. 103. t. 39. f. 6. and "Coralloides cupressiforme, capitulis globosis," Dill. Musc. 117. t. 17, f. 35, but it is likely he only saw illustrations of this material. Thus, following the precedent set by Degelius (1954, pp. 451) in the typification of Lichen fascicularis Linnaeus, a specimen in the Linnaean Herbarium was chosen as the type. This is also in accordance with the "Guide of the Determination of Types" in the International Code of Botanical Nomenclature (Stafleu, 1972; pp. 75) which states that "Other things being equal, a specimen should be given preference over pre-Linnaean or other cited descriptions or illustrations when lectotype of species or infraspecific taxa are designated." In my opinion the material that should be selected as the type of Lichen globiferus is in the Linnaean Herbarium. Savage (1945, pp. 199) lists number 252, as Lichen globiferus written by Linnaeus fil. Specimen 251 in the herbarium is listed as Lichen globifer, but Savage is uncertain about the handwriting although he attributes it to Linnaeus fil. As there is some question as to the handwriting for specimen 251 it is my feeling that specimen 252 will turn out to be the most appropriate lectotype.

As the original material of neither Lichen globiferus Linnaeus nor Lichen globosus Hudson has been seen, these two critical species cannot be placed in synonomy at the present time although they are commonly regarded as the same species. Alternatively, if the Dillenian illustration of "Coralloides cupressiforme, capitulis globosis," were designated as the type of Lichen globosus Hudson (see page 74) and as the type of Lichen globiferus Linnaeus, these two species could be put in synonomy immediately. Since material of Lichen globiferus is available, which Linnaeus actually studied, I prefer not to base this species on an illustration.

Sphaerophoron australe Laur. is the holotype of Bunodophoron Mass. as this is the only new combination that has been published.

Description.--Thallus foliose or fruticose, erect to decumbent, typically well branched. Medulla solid or hollow. Apothecia 1-several produced on the terminal, subterminal or laminal areas of the primary branches. Mazaedia at first enclosed, then becoming exposed by the irregular rupturing of the surrounding receptacle. Asci cylindric, thin-walled, containing 8 spores arranged in a single row. Spores spherical or occasionally broadly ellipsoid, nonseptate, brown, grayish or blue to dark green. Typically surrounded by a dark carbonaceous material, 5.0-15.0 μ in diameter.

Key to the Subgenera of the Genus Sphaerophorus

1. Thallus branches compressed or broadly flattened; mazaedia oriented subapically to ventrally 2
1. Thallus branches terete, never compressed; mazaedia oriented apically 3
   2. Thallus branches narrowly compressed, less than twice as broad as thick; mazaedia generally oriented subapically; spores gray, 5-10 μ in diameter. BUNODOPHORUS
   2. Thallus branches broadly flattened, generally more than twice as broad as thick; mazaedia oriented ventrally; spores brown, 8-15 μ in diameter. . AGHIMUS
3. Cortex thin (less than to 45 μ thick); spores spherical, grayish to hyaline . . . . SPHAEROCARPUS
3. Cortex more than 45 μ thick; spores ovate or spherical, green to dark blue . . . . SPHAEROPHORUS

Artificial Key to the Species

1. Thallus branches solid 2
1. Thallus branches hollow 24
   2. Thallus branches terete, displaying similar color and shape around the entire lobe; mazaedia oriented apically 3
   2. Thallus branches compressed at least near the base; lower surface lighter in color than upper surface; mazaedia oriented subapically or ventrally 9

3. Medulla I + blue 4
3. Medulla I - 5
    4. Thallus well developed, branches with numerous coralloid ramuli; cephalodia present. Endemic to New Zealand . . . . STEREOCAULOIDES
    4. Thallus smaller, with or without coralloid ramuli; cephalodia absent. Circumboreal with outliers in southern South America and the Falkland Islands. . GLOBOSUS
5. Branches typically with small coralloid or isidioid outgrowths 6
5. Branches lacking coralloid or isidioid outgrowths 7
    6. Branches with isidioid structures; spores 5.5-8.0 μ in diam.; cortex KOH - . Tropical to subtropical distribution . . . . FORMOSANUS
    6. Branches generally with small coralloid ramuli; spores 8.0-9.5 μ in diam.; cortex yellow and KOH + yellow, containing isousnic acid. Southern hemisphere distribution . . . . RAMULIFER
7. Cortex paper-thin, 30-45 μ thick; spores spherical, grayish 6.5-10.0 μ in diam. Southern hemisphere distribution . . . . TENER
7. Cortex over 45 μ thick; spores ovate or spherical, green to dark blue, 8.0-11.0 μ in diam. Occurring only in the northern hemisphere 8

8. Thallus short, 1-2 cm in length; surface dull, often delicately pitted or subrugose; terricolous or saxicolous. Arctic-alpine circumboreal . . . . . . FRAGILIS

8. Thallus better developed; surface smooth; corticolous. Endemic to Japan . . . . MEIOPHORUS

9. Cortex yellowish, KOH + yellow, isousnic acid. Southern hemisphere distribution . . . . RAMULIFER

9. Cortex grayish green, KOH -, lacking isousnic acid . . . 10

10. Main branches distinctly flattened, more than twice as broad as thick 11

10. Main branches subterete to slightly compressed, less than twice as broad as thick 17

11. Containing protocetraric acid, PD + reddish 12

11. Lacking protocetraric acid, PD -, rarely PD + pale orange containing stictic acid 15

12. Apothecia lacking isidioid ramuli; mazaedia oriented subapically to ventrally; spores brown, 6.5-10.0 μ in diam. 13

12. Apothecia generally with small isidioid ramuli on the margin and/or on the upper surface; spores brown, 10.0-10.5 μ in diam. 14

13. Fertile branches 1-1.5 cm in length, plain, rarely branched; apothecia 1.5-4.0 mm across. Southern South America and the Auckland Islands . . . . IMSHAUGII

13. Fertile branches 1.5-2.5 cm in length, with numerous basally located sterile ramuli; apothecia 1.0-1.5 mm across. Endemic to Australia. . . . . COOMERENSIS

14. Primary branches generally broader than 2 mm across; apothecia up to twice as broad as the supporting fertile branch; mazaedium when mature partially covered. Southern hemisphere distribution . . INSIGNIS

14. Primary branches up to 2.5 mm across; apothecia similar in size to the supporting fertile branch; mazaedium well exposed at maturity. . . . . . . MURRAYII

15. Branches robust, broadly flattened, 4-12 mm across; lacking sphaerophorin. Southern hemisphere distribution . . . . SCROBICULATUS

15. Branches generally smaller, 2-6 mm wide; producing sphaerophorin 16

16. Fertile stem rarely branched; primary branches thinly flattened with typically thickened margins becoming somewhat convoluted near the apothecium; apothecia 1.5-4.0 mm across. Southern hemisphere distribution . . . . PATAGONICUS

16. Fertile stem commonly branched near the base; margins not especially thickened nor convolute; apothecia distinctly enlarged, 4-6 mm across, flaring outwardly from a 2 mm wide fertile branch when mature; when young distinctly enlarged and globose. Southern hemisphere distribution . MACROCARPUS

17. Medulla containing protocetraric acid, PD + red 18

17. Medulla lacking protocetraric acid, PD - or PD + orangish containing or lacking stictic acid 21

18. Primary branches weakly decumbent, elongate, 2-7 cm in length; spores 12-15 μ in diam. . . . MURRAYII

18. Primary branches decumbent or erect, short 1.0-2.5 cm in length; spores, 5.4-10.0 μ in diam. . . 19

19. Apothecia with occasional short dentate or flabellate isidioid structures on the upper surface; spores grayish 5.4-7.0 μ in diam. Auckland Islands and New Zealand . . . . MICROSPORUS

19. Apothecia lacking isidioid outgrowths on the upper surface; spores brownish, 6.5-9.5 μ in diam. 20

20. Fertile branches 1.0-1.5 cm in length, plain, rarely branched; apothecia 1.5-4.0 mm across. Southern South America and the Auckland Islands . . . . IMSHAUGII

20. Fertile branches 1.5-2.5 cm in length, with numerous basally located sterile ramuli; apothecia 1.0-1.5 mm across. Endemic to Australia . . . . COOMERENSIS

21. Primary branches terete to subterete, lined with small cylindrical isidioid structures along the upper surface. Tropical and subtropical distribution . . . FORMOSANUS

21. Primary branches subterete to narrowly compressed, lacking isidioid structures along the upper surface 22

22. Thallus with thin elongated attenuating ramuli typically originating near the base of the much larger fertile branch; upper part of branch smooth, without ramuli. Ceylon, Borneo, and New Caledonia . . . . KINABALUENSIS

22. Thallus without the elongated attenuating basal ramuli; branching more irregular 23

23. Apothecia smooth, distinctly situated above the shorter sterile ramuli; mazaedia well exposed and free from the receptacle; containing sphaerophorin and an unknown substance. Endemic to Valdivian and Nahuel Haupi Regions of Chile and Argentina . . . . DODGEI

23. Apothecia smooth or more commonly with small irregular ramuli emanating along the margin; mazaedia exposed but typically sunken within the receptacle; PD - or PD + containing sphaerophorin and usually stictic and constictic acids. Worldwide oceanic distribution . . MELANOCARPUS

24. Thallus with regular and mostly dichotomous swollen branches; apothecia laminal on the lower surface. Endemic to Madagascar . . . . MADAGASCAREUS

24. Thallus with more irregular branches; apothecia terminal on the primary branches. Madagascar to Southeast and eastern Asia . . . . DIPLOTYPUS

Subgenus SPHAEROCARPUS Ohlsson, subg. nov.

Thallus ramis teretibus; apothecia terminalia; mazaedia erecta; sporae hyalinae, globosae, 6.5-10.0 μ diam.

Type species: Sphaerophorus tener Laur.

This subgenus consisting of one species seems to be quite unrelated to any other species of Sphaerophorus. The thin cortex, smooth terminal apothecia and colorless spherical spores are characters which combine to make this a distinct subgenus.

1. Sphaerophorus tener Laur.

Linnaea 2: 45. 1827. Type: Australia, Sieber s.n. (PC, lectotype; FH, isolectotype).

Sphaerophoron australe Hook. f. & Tayl. London J. Bot. 3: 653, 1844 (non Laurer, 1827) [≡ Sphaerophorus taylori Dodge], Nova Hedwidgia 19: 489. 1970. Type: Auskland I., 1840 Hooker (FH-Tayl. 246, lectotype).

Sphaerophoron curtum Hook. f. & Tayl. London J. Bot. 3: 654. 1844. Sphaerophoron tenerum var. β curtum Tayl. & Hook. Fl. Antarct. 1: 195. 1844. Sphaerophorus globosus var. curtus (Tayl. & Hook.) Zahlbr. Cat. Lich. Univ. 1: 692. 1922. Type: Auckland I., 1840 Hooker (FH-Tayl. 153, lectotype).

Sphaerophorus tenerum f. compactum Cromb. J. Linn. Soc., Bot. 15:223. 1876. Type: Puerto Gallant, Straits of Magellan, 1867 Cunningham (BM, lectotype; BM, isolectotype).

Sphaerophorus tener f. *globosoides* Murr. Trans. Roy. Soc. New Zealand 88: 194. 1960. Type: New Zealand, South I., Otago, near Pulpit Rock Silver Peaks, *Murray 4288* (BM, isotype).

Nomenclatural Remarks

Sphaerophoron curtum Hook. f. & Tayl. was published as new species based on a collection of short, very caespitose material of *S. tener* Laur.

A fertile specimen labeled "ex Crombie" and annotated as *S. tenerum* f. *compactum*, housed in the British Museum and collected by Cunningham in Puerto Gallant is selected as the type specimen. Another specimen in the British Museum, which seems to be a piece of the Crombie material, has been designated as an isolectotype.

Description

Thallus morphologically variable, producing elongate, fertile, erect primary branches to shorter, sterile, almost corymbose, secondary branches. Forming as small to large cushions on the trunks and branches of trees or wood; occasionally forming extensive patches on the soil up to 1 meter in width. Primary branches terete, elongate, sparse to frequently branched to 7 cm in length, 0.6-1.2 μ in width. Surface nitid, pale green to brown. Cortex thin, 30-45 μ, composed of thick-walled, gelatinized and fused hyphae, intricated in various directions and covered by a thin (2-3 μ), colorless epicortex. Algal-medullary layer 15-25 μ thick, continuous beneath the cortex, surrounding the entire lobe, occasionally occurring as isolated cells on the lower side; algae, protococcoid, spherical, 8-10 μ in diameter. Medulla composed of thick-walled, colorless hyphae 6-9 μ in diameter, partially fused, forming a dense central strand. Apothecia common, subglobose to globose, terminal, 0.8-1.5 mm in diameter. Mazaedium oriented apically, becoming exposed at an early stage of development by the irregular apical rupturing of the enclosing receptacle; when mature partially surrounded by the receptacle or more commonly free and prominent; when free from the receptacle a smooth margin is seen to form around the base of the mazaedium; the outermost spore layer of the mazaedium seemingly becoming gelatinous, forming an outer enclosing layer. Asci cylindric, near maturity 40-65 X 5-8 μ, containing 8 spores arranged in a row. Spores spherical hyaline to grayish, 6.5-10.0 μ in diameter. Pycnidia common in terminal areas.

Medullary reactions.--PD -, KOH -, KC -, C -, I -.

Constituents.--Sphaerophorin was the only lichen substance found in the 487 specimens examined.

Discussion

Superficially *S. tener* resembles members of the subgenus *Sphaerophorus* with terete branches and terminal apothecia. However, other morphological features, such as a distinctly thinner cortex, production of a mazaedial covering, differences in spore size, shape and color, loss of surrounding receptacle in mature apothecia and the production of only sphaerophorin are, in my opinion, sufficiently distinctive to place this species in a subgenus of its own.

Sphaerophorus tener is a widely distributed southern hemisphere oceanic species (see Figure 40) and is found in a variety of habitats, occurring over rocks, decomposing wood, and on barren soil in open areas and in protected places it occurs on branches and trunks of trees.

Material Examined

Exsiccati seen.--Arn. 1210 (BM, H, H-Nyl. 562); Mälme Austro. 381 (H, BM, MSC), 404 (H, BM, MSC US); Weber 294 (MSC, MICH).

Specimens seen.--NEW ZEALAND. locality unknown, coll. unknown (US, BM), Jolliffe s.n. (BM), Knight s.n. (BM); NORTH I. locality unknown, Colenso s.n. (BM), Colenso 2716 (WELT), 1762 (BM, WELT); Trounson Kauri Park, 1966 Wade (BM); Whakapapa Tongariro Natl. Park, 1966 Wade (BM); [Wa Ma Ku], Setchell 59 (FH); Flagstaff, Murray 01167 (OTA); Te Hawera, Colenso 2822 (WELT), Colenso 2717 (WELT); Mt. Tararua, Buchanan s.n. (BM), 1882 Buchanan (BM), Colenso 2124 (WELT); Ruahine, Colenso 4560, 2715, 2730 (WELT); Ruamahanga River, Colenso 2183 (WELT); Te Aroha, Leland & Chase 272 (FH, US, BM, MSC); Te Apiti, 1899 Beckett (BM); near Wellington, Buchanan s.n. (BM), Buchanan 27 (OTA). SOUTH I. Port Nicholson, Lyall s.n. (BM); Nelson: Nelson, coll. unknown (BM), Cobb River Dam, Mason 601, 624, 621 (OTA), Lake Rotoiti, Clear Creek, Taylor L-36147 (CAN), 8 mi. E of Reefton along Route 7, Imshaug 55838 (MSC), Buller Gorge, 17.1 mi. W. of Inangahua Junct., Imshaug

55808 (MSC), Lewis Pass, 12 mi. E. of Springs Junct., Imshaug 55713 (MSC); Westland: no locality, [Archer] 33, 34 (BM), Franz Josef Glacier, 1959 Boey (OTA), Greymouth, 1886 Helms (H), Lake Wombat, Imshaug 48015 (MSC); 8 mi. W of Turiwhate, Imshaug 48082, 48122 (MSC), Harris 6367 (MSC), Gillespies Cook River Road, between Tornado Creek and Whelan Creek, Harris 6234 (MSC) near Hercules Creek on Route 6, Harris 6185 (MSC), Lake Wahapo, Harris 6325 (MSC), S margin of Lake Wahapo, Imshaug 48064 (MSC), Malvern: Bealey Glacier Vista, Imshaug 48152 (MSC), Harris 6386, 6406 (MSC), lower part of Avalanche Peak track, Harris 6462 (MSC), Punchbowl Creek Track, Imshaug 48192 (MSC), Canterbury: locality unknown, 1860-61, Sinclair & Haast (BM), Port Levy, 1896 Beckett (BM), Hunley Forks, Lake Ohau, Murray 6854 (OTA); Otago: Catlines, Lake Wildie, 1961 Mark (OTA), N. Aspiring Peak, upper Routeburn, Mark s.n. (OTA), near Routeburn Huts, Humboldt Mt., 1968 Scott (OTA), Hollyford Valley, 1945 Corbett (OTA), Morrison Creek, Leith Valley Road, Imshaug 55943 (MSC), Track near Pulpit Rock, Silver Peaks, Dunedin, Murray 4288 (BM), Silver Peak, Murray 4287 (OTA); Southland: Howden, Murray 0835 (OTA), Milford Sound, Imshaug 57929 (MSC), Secretary I., Murray 4056, 4057 (OTA), 4058 (BM), Doubtful Sound, Wylie 1728/5 (BM). STEWART I. S. coast, Martin 651 (BM), Mt. Anglens, 1946 Martin (OTA), Port Pegasas, Imshaug 57817 (MSC), Murray 0416, 077 (OTA). - AUCKLAND ISLAND. locality unknown, coll. unknown (BM, H-Nyl. 40364); locality unknown, 1901-04 Martindale (BM), Hooker s.n. (BM), 1840 Hooker (FH-Tayl. 146, 144), 1874 Krone (US, BM), Hombron s.n. (H-Nyl. 40368), 1854 Home (BM); Enderby I., 1840 McCormick (BM), 1901-04, Discovery Exp., (BM), Imshaug 56306, 56324

(MSC); "Point," 1840 McCormick (BM): Ewing I. Fineran 1464 (CANTY-U), Imshaug 56446 (MSC); Laurie Harbour, Fineran 1751 (CANTY-U); Ranui Cove, Imshaug 57173, 56177, 56230 (MSC); Rose I., Imshaug 56354 (MSC); WNW end of Chambers Inlet, Imshaug 56246 (MSC); ridge SE of Mt. Easton, Imshaug 56514 (MSC); between Musgrave Inlet and Lake Hinemoa, Imshaug 56456 (MSC); Musgrave Harbour, Imshaug 57074 (MSC); Musgrave Inlet, Imshaug 56576 (MSC); Hooker Hills, Imshaug 56664 (MSC); between Hooker Hills and Erebus Cove, Imshaug 56700 (MSC); Terror Cove, Imshaug 56708 (MSC); Lookout Pt., Imshaug 56830 (MSC); Cape Cove, Carnley Harbour, Imshaug 56914 (MSC); Carnley Harbour, N of Figure Eight I., Imshaug 57040 (MSC); Adams I., Imshaug 56981, 57123, 57152, 57424 (MSC); between Smith Harbour and Normon Inlet, Imshaug 57221(2) (MSC); Mt. Raynal, Imshaug 57289, 57317 (MSC); Mt. D'Urville, Imshaug 57350 (MSC); Granger Inlet, Imshaug 57641 (MSC); Hanfield Inlet, Imshaug 57733 (MSC). - CAMPBELL ISLAND. locality unknown, coll. unknown (US, BM); locality unknown, Poppleton 5543, 5544 (BM), Poppleton s.n. (US), Bailey 1630 (BM), 1840 McCormick (BM), 1874 Filhol (H-Nyl. 40363 & 40366, US, FH, BM, PC), 1840 Hooker (FH-Tayl. 146, BM), Lehnert s.n. (MICH): Paris-Villarceau ridge, Imshaug 46611, 46613 (MSC); Mt. Fizeau, Imshaug 46776 (MSC); Moubray Hill, Imshaug 46925, 46936 (MSC); above Venus Cove, Imshaug 47081 (MSC); between Tucker and Camp Coves, Imshaug 46218 (MSC), Harris 4681, 4659 (MSC); S of Tucker Cove Station, Harris 4879 (MSC); along road to old Tucker Cove Station, Harris 4474, 4455 (MSC); Beeman Hill, Imshaug 47038 (MSC), Harris 4547 (MSC); N of Beeman Station, Harris 4601 (MSC); Mt. Azimuth, Imshaug 46565 (MSC); sea cliffs between Mt. Azimuth and

Courrejolles Peninsula, Imshaug 46322 (MSC); spur leading to bay opposite Dent Island, Imshaug 46255, 46251 (MSC); Mt. Honey, Imshaug 47424B, 46347 (MSC), Harris 4923 (MSC); Fihol-Honey saddle, Imshaug 46006 (MSC); above Garden Cove at base of Mt. Honey, Imshaug 47137 (MSC); head of Garden Cove toward Filhol Peak, Harris 5193 (MSC); Filhol Peak, Harris 5592, 5077, 5076, 5061 (MSC); Mt. Dumas, Imshaug 46970 (MSC), Harris 4998, 5021 (MSC); between Penguin Bay and Menhir Peak, Harris 4718, 4715 (MSC); St. Col Peak, Imshaug 45949, 45930 (MSC), Harris 5336 (MSC), coll. unknown 5425 (FH, BM); S side of Perseverance Harbour, Harris 5420, 5419, 5293 (MSC), Imshaug 47188, 47161B (MSC); N side of Perseverance Harbour, Harris 4317 (MSC); Lyall Ridge, Harris 4434, 4422, 5513, 5520 (MSC), Imshaug 46145 (MSC); Mt. Lyall, Harris 4767 (MSC); across from Shoal Point, Imshaug 46073 (MSC); Mt. Lyall pyramid, Imshaug 46505 (MSC); Mt. Sorenson, Imshaug 47306 (MSC); E of Mt. Sorenson, Harris 5177, 5157, 5154 (MSC); NW of Sorenson Hut, Imshaug 47236 (MSC). - MACQUARIE ISLAND. locality unknown, Laird 257 (BM); Pyramid Peak, 1971 Buckney (MSC). -

AUSTRALIA. no locality, Sieber s.n. (PC, FH), Oldfield s.n. (FH, US); Mountain River, Oldfield s.n. (US); Bank's Is., 1787 Menzies (BM); VICTORIA. Mt. Ellery, Merratt s.n. (FH-Tayl. 157, FH), Turton's Way, Bratt 69/785 (MSC), Blue Range, Filson 6519, 6519a, 4998 (MEL), Indian Head Mts., Beauglehold 4272 (MEL), Mt. Boobyalla, Filson 7039 (MEL), Mt. Baw Baw, 1952 Dakin (MEL), Lake Mt., NE of Marysville, 1952 Willis (MEL): QUEENSLAND. Lamb's Head, Vievers 18224 (MEL); NEW SOUTH WALES. Darby Munro Hut, Gloucester Tops, Filson 5620 (MEL). - TASMANIA. locality unknown, coll. unknown (BM, FH-Tuck. 3744), 1840 Hooker (FH-Tayl. 145), Oldfield s.n. (FH, US); Table Mt., Brown 524 (BM); Mt. Arthur, Wilson 1137 (FH); Mt. Eliza, 19 mi SW of Maydena, Bratt 71/814, 71/824, 71/818 (MSC); Adamsfield, Bratt 68/151 (MSC); near Pine Lake, 14 mi. SSW of Deloraine, Bratt 68/71a (MSC); Ball Room Forest, 41 mi. S of Burnie, Bratt 67/606 (MSC); Mt. King William, Bratt 1536 (MSC); Mt. Hartz, SW of Queenstown, Bratt 68/1489 (MSC); Mt. Pitt, Bratt 1536 (BM); Cynthia Bay NW of Derment Bridge, Cannell 70/583 (MSC); S peak of Mt. Darwin, Bratt 71/952 (MSC).

JUAN FERNANDEZ. MAS A TIERRA: S side of ridge to El Piramide from Portezuela de Villagra, Imshaug 38290 (MSC). - CHILE. locality unknown, 1864 Krause (H), Gay s.n. (H-Nyl. 40361); Andes of Patagonia, Lobb s.n. (BM), Valpariso 1846 Puccio (BM). Prov. Magallanes: Islet S of Isla Ruiz, Isla Guarello, Imshaug 44046 (MSC), Isla Madre de Dios, Imshaug 44130, 44154, 44155 (MSC), Isla Juan, B. Wide, Imshaug 44201, 44214, 44230 (MSC), Isla Chatham, E of B. Wide, Imshaug 44269, 44295, 44316, 44345, 44353 (MSC), Caleta Amalia, Imshaug 44422, 44458 (MSC), S part of Tierra del Fuego, 1833 Darwin (BM), Straits of Magellan, coll. unknown (BM, PC, US, H-Nyl. 40365), McWhinnie s.n. (BM), Jacquinot s.n. (PC), 1841 Hombron (FH-Tuck. 3750), d'Urville (PC), 1767 Commerson (PC), Cape Horn, Isla Hermite, Hooker 28 (BM), Cape Horn, Hooker s.n. (BM), St. Martin Cove, Hooker s.n. (BM), Seno Almirantazgo, I. Grande, off Canal Whiteside, 1910 Benove (FH), Seno Contraalmirante Martinez, I. Grande, off Canal Magdalena, 1929 Roivainen (H), Brunswick

Peninsula, P. Gallant, LeGuillou 14 (PC), 1867 Cunningham (BM), 1868 Cunningham (BM), Brunswick Peninsula, B. Fortescue, Imshaug 44922, 45001, 45061 (MSC), Brunswick Peninsula, B. San Nicolas, Imshaug 45575 (MSC), Brunswick Peninsula, P. Cutter, Imshaug 39336, 39359, 39380, 39383, 39548, 39608, 39611, 39649 (MSC), B. Borja, Isla Riesco, Imshaug 45148, 45189 (MSC), I. Desolacion, P. Angusto, Dusén 172 (FH, US, CAN), B. Tuesday, Imshaug 44683, 44692 (MSC), P. Churruca, Imshaug 44813, 44851, 44880 (MSC), 1898 Savatier (H-Nyl. 40367), P. Bueno Imshaug 44602, 44494, 44493 (MSC), 1872 Hill (FH-Tuck. 3744), Caleta Barrow, Isla Diego, 1900 Ferrari (H), Capitán Arecena, 1929 Roivainen (H), I. Grant, P. del Morro, Imshaug 43681 (MSC), I. Pilot, P. del Morro, Imshaug 43770 (MSC), Caleta Cockle, I. Pilot, 1879 Coppinger (BM), B. Ventisquero, I. Riesco, 1872 Hill (DUKE, US, FH, BM, CAN, MICH, MSC), Isla Manuel Rodriquez, Bahia Sholl, 1868 Cunningham (BM), I. Otter, Canal Smyth, 1868 Cunningham (BM), Isla Mornington, P. Alert, Imshaug 43838, 43867, 43877, 43884, 43955, 43960 (MSC), Isla Williams, B. Tribune, Imshaug 43420, 43440 (MSC), Isla Wellington, P. Eden, Junge 564 (H), Ball s.n. (BM), Imshaug 43485, 43500, 43513 (MSC), Isla Wellington, P. Charrua, Imshaug 43591, 43603, 43607, 43622, 43803 (MSC), B. Halt, Canal Messier, Cunningham s.n. (BM); Prov. Aisen: P. Barroso, 1868 Cunningham (BM), Puerto Island, Imshaug 43218, 43222, 43229, 43241, 43246, 43247, 43267, 43284, 43295 (MSC), near glacier, Fiordo Tempano, Imshaug 43314, 43341 (MSC); Prov. Chiloe: locality unknown, coll. unknown (BM), Claude-Joseph 3258 (FH, MSC, US), King s.n. (BM), I. Guaitecas, April

1897 Dusén (H, FH), Isla Mulchey, P. Ballena, Imshaug 43179, 43182, 43188 (MSC), Archipielago de los Chonos, Darwin s.n. (BM), Piruquina, Junge 85 (H), Cordillera San Pedro, Godley 449 (MSC, FH, BM); Prov. Valdivia: Dept. LaUnion, Llancacura, Mahu 1648 (FH), Cordillera Pelada, 1932 Hollermayer (H); prov. Osorno: along road at Refugio Antillanca, Imshaug 42922, 42928, 42934, 43041 (MSC), valley of Rio Nauto, Refugio Antillanca, Imshaug 43094 (MSC), Cordillera del la Carpa, Eyerdam 10898 (BM, US, H). - ARGENTINA. I. Estados: B. Crossley, Imshaug 50536A, 50544B, 50663, 50752, 50781, 50795, 50819, 50829 (MSC), I. Observatorio, Imshaug 50984, 51000 (MSC), I. Alferez Goffre, Imshaug 51028 (MSC), P. Roca, Imshaug 51104, 51133, 51210, 51222 (MSC), P. Basil Hall, Imshaug 51286, 51322, 51369, 51382 (MSC), P. Cook, Imshaug 51425, 51706, 51714, 51578, 51596 (MSC), P. Cook/Vancouver, Imshaug 51513 (MSC), P. Vancouver, Imshaug 52042, 52086, 52132, 52211 (MSC), P. San Juan, Imshaug 51754, 51808, 51909, 52020 (MSC); B. Primera, Imshaug 52291, 52378, 52444 (MSC), P. Celular, Imshaug 52488, 52522, 52569, 52635, 52670, 52685, 52731 (MSC), P. Alexander, Imshaug 52801 (MSC), B. Capitan Canepa, Imshaug 52874, 52927, 52009, 53043 (MSC), Cabo San Bartolome, Imshaug 53158, 53195, 53218 (MSC), B. Flinders, Imshaug 53269, 53319, 53353, 53389, 53392, 53404 (MSC), P. Hoppner, Imshaug 53691, 53729, 53751, 53778, 53831 (MSC), P. Parry, Imshaug 53851, 53886, 53942, 54011 (MSC). I. Grande: B. Buen Suceso, Imshaug 49971, 50023 (MSC), B. Valentin, Imshaug 50434, 50454 (MSC). Patagonia: locality unknown, 1896-97 Hatcher (MSC), 1888 Voyage of Albatross (BM, F), 1887-88 Lee (US); Prov. Rio Negro, Cerro Mayo, James 1427 (BM); Prov. Neuquen, Kull 2601

(BM). Tierra del Fuego: locality unknown, coll. unknown (FH, FH-Tuck. 3744). - FALKLAND IS. locality unknown, 1844 Lyall (FH-Tayl. 148), Hooker 12 (BM); W. FALKLANDS: Weddell I., Imshaug 41903, 41945, 41987 (MSC), Port Howard, Freezer Rocks, Imshaug 41354 (MSC), Hill Cove, summit Mt. Fegen, Imshaug 41205 (MSC), Sharp Peak, Imshaug 41249 (MSC), West French Peak, Imshaug 40949, 40958 (MSC); E. FALKLANDS: Port William, Mt. Low, Imshaug 41584 (MSC), Mt. Harriet, Imshaug 41543 (MSC), Goat Ridge, Imshaug 41508 (MSC), Mt. Kent, Imshaug 40482, 40449, 40421 (MSC), Two Sisters, Imshaug 40382, 40352 (MSC), Sapper Hill, Imshaug 39744, 39782 (MSC), Tumbledown Mt., Imshaug 39699, 39666 (MSC).

Subgenus SPHAEROPHORUS

Thallus branches terete; apothecia terminal; mazaedia becoming exposed at the apical end of the apothecia; spores blue or green, ellipsoid or spherical, 8-10 μ in diam.

Type species: *Sphaerophorus globosus* (Huds.) Vain.

This subgenus consists of four species with *S. meiophorus*, *S. fragilis*, and *S. globosus* seemingly forming a closely allied group. The fourth species, *S. stereocauloides*, is endemic to New Zealand and more distantly related, differing in several aspects. Another endemic, *S. meiophorus* is known only from Japan. *Sphaerophorus fragilis* has a high-arctic circumboreal distribution and *S. globosus* has a temperate oceanic circumboreal distribution with outliers in southern South America and the Falkland Islands (see Figure 39).

2. _Sphaerophorus fragilis_ (L.) Pers.

Neue Annal. der Bot. 1: 23. 1794. _Lichen fragilis_ L. Spec. Plant. 1154. 1753. _Lichen globiferus_ β _fragilis_ Neck. Method. Muscor. 17: 67. 1771. _Verrucaria fragilis_ Humb. Flora Friburg Specim. 42. 1793. _Coralloides fragile_ Hoffm. Descript et Adumbr. Plant. Lich. 2: 34. 1794. _Stereocaulon fragile_ Hoffm. Deutschl. Flora 131. 1795. _Sphaerophoron coralloides_ β _fragile_ Mudd, Man. Brit. Lich. 8: 264. 1867. Type: Sweden, Flora Suecia 983 (Linn. Herb. 1273-262; S, lectotype).

Nomenclatural Remarks

In his description of _S. fragilis_, Linnaeus included three citations: "Lichen erectus ramosissimus, ramulis teretibus nudis filiformibus obtusis." Fl. lapp. 440 t. 11. f. 4., "Coralloides alpinum, corallinae minoris facie." Dill. musc. 116. t. 17. f. 34. and "Lichen fruticulosus solidus, ramulis teretibus obtusis." Fl. Suec. 983. As the latter specimen was studied by Linnaeus and is included in the Linnaean Herbarium, I believe it should be chosen as lectotype.

Description

Thallus small, caespitose, forming close irregular 5-10 cm broad cushions on rock and barren soil. Primary fertile branches, terete, upright, to 25. (3.0) cm in length; sterile branches crowded, interlaced with each other, small 2-3 cm in length, 0.6-0.8 (1.0) mm in width. Secondary branching sparse, irregular, normally occurring near the apices to form small terminal tufts. Surface dull brown, to brownish gray, typically delicately pitted or subrugose, occasionally transversely annulate-cracked in larger fertile branches. Cortex 60-110 μ thick, composed of thick-walled, gelatinized, fused hyphae, intricated in various directions and covered by a thin (1-2 μ) colorless epicortex. Algal-medullary layer 15-25 μ thick, encircling the medulla; algae protococcoid, spherical 6.5-9.0 μ in diameter. Central medulla composed of thick-walled, longitudinally arranged, hyaline, partially fused and dense hyphae, 4-8 μ in diameter. Apothecia occasional, subglobose, terminal, 0.8-2.0 mm across. Mazaedium oriented apically, exposed at an early stage of development by the apical rupturing of the enclosing receptacle. Asci cylindric, near maturity 45-70 X 6-8 μ, containing 8 spores arranged in a single row. Spores spherical or broadly ellipsoid, greenish becoming blue when mature, 8.0-10.0 μ in diameter. Pycnidia occasional, occurring in the apical areas; microconidia, rod-shaped, 3-5 X 1 μ.

Medullary reactions.--PD -, KOH - or occasionally KOH + violet, KC -, I -.

Constituents.--Sphaerophorin, squamatic acid, and hypothamnolic acid.

Sphaerophorus fragilis consists of four chemotypes, one of which is of the substitution type with hypothamnolic acid replacing squamatic acid. Another chemotype is of the additive type with both squamatic and hypothamnolic acids present or both absent; in the latter case sphaerophorin occurs by itself.

Chemotype I.--Sphaerophorin and hypothamnolic acid (see Figure 41). The type specimen of *S. fragilis* and 43% of the 87 European specimens examined were of this chemotype, while in North America only 6% contained these substances. This chemotype was not found in Japan.

Chemotype II.--Sphaerophorin (see Figure 42). This chemotype seems to be randomly distributed in both North America and Europe with 6-8% of the specimens failing to produce any substances other than sphaerophorin.

Chemotype III.--Sphaerophorin and squamatic acid (see Figure 43). In North America nearly 80% of the 96 specimens were of this chemotype, which compares closely with the Japenese material, all of which was found to contain squamatic acid. By contrast, in Europe only 22% of the specimens contained sphaerophorin and squamatic acid.

Chemotype IV.--Sphaerophorin, squamatic acid and hypothamnolic acid (see Figure 44). This chemotype is more common in Europe with 29% exhibiting these substances. In North America only 6% of the specimens were of this chemotype.

As has been found in other species of *Sphaerophorus*, *S. fragilis* has several chemotypes which are morphologically indistinguishable, but have a definite tendency for occurring in geographically distinct areas.

Discussion

Sphaerophorus fragilis can be distinguished from the closely allied *S. meiophorus* by its small caespitose nature, dull cortex, fairly dense medulla and specificity of substrate to rock or barren soil. Along with these previously mentioned features, it can be separated from *S. globosus* by its medullary hyphae failing to react to IKI. In sterile deformed material of *S. globosus* whose IKI medullary reaction is weak, the specimens are difficult to separate from *S. fragilis*.

Sphaerophorus fragilis has a high-arctic circumpolar oceanic distribution occurring in more southerly latitudes only in alpine areas. As related in the previous paragraph, this species has been found to occur only on soil or rock and is the only species of *Sphaerophorus* to do so.

Material Examined

Chemotype I (Sphaerophorin and
hypothamnolic acid)

Exsiccati seen.--Anzi It. 34 (FH); Flor. Hung. 112 (FH); Hepp Fl. Eur. 665 (FH-Tuck. 3751); Mig. 20 (MICH); Moug. 263 (FH-Tayl. 147, FH); Pisut 53 (MSC); Rab. 194a (FH, MICH); Reich. & Schub. 375 (FH); Stenh. 59 (MICH, FH-Tuck. 3752).

Specimens seen.--NEW HAMPSHIRE. Coos Co.: Mt. Washington, Sept. 1904 *Merrill* (CAN, FH). - NEWFOUNDLAND. locality unknown, 1894 *Robinson & Schrenk* (FH). - QUEBEC. Rimnouski, Fort George, *Lapage 6274* (CAN, MICH). - FINLAND. Uusimaa, Kyrslätt, coll.

unknown (FH); Nousiaimen, Kaisela, 1967 Laine (DUKE); Enontekiö, S-Luossunibba, 1956 Huuskonen (DUKE). - SWEDEN. locality unknown, Linnaeus (BM-Linnaean Herb. 1273-361, Flora Suec. 983), coll. unknown (Linnaean Herb. 1273-260); UPPSALA: locality unknown, 1854 Th. Fries (FH-Tuck. 3752), 1859 Blomberg (DUKE); STOCKHOLM: Sorunda, 1888 Laurell (CAN); KOPPARBERG: Idre, Städjan, 1930 Hasselrot (CAN), Dalecarlia, Bispberg Klack, 1896 Vrang (FH); ÖREBRO: Närke, Svennevad, 5 July 1950 Kjellmert (CAN); GÖTEBORG OCH BOHUS: Skaftö, Kristineberg, 1929 Hasselrot (CAN), Vrango I., Styrso parish, 1960 Nordin (DUKE, TNS). - NORWAY. HORDALAND: Maursat i Lysendal, 1907 Havass (DUKE), Buardalen i Odda, 1917 Havaas (DUKE), near Granvin, Havaas s.n. (DUKE), 1937, 1902, 1896 Havaas (DUKE), 1940 Havaas (MICH); OPLAND: Dovre, coll unknown (FH); NORDLAND: Jutulfjellet, 1910 Lynge (FH), Brónnóg, 1906 Havaas (DUKE). - GERMANY. Magdeburg, Brocken, Knop s.n. (MICH); Bayern, Glaserberg, Grumman 1705 (MSC). - FRANCE. VOSAGE: locality unknown, Duby s.n. (FH); HAUTE-SAVOIE: Mt. Blanc, 1959 Ullrich (MSC). - SWITZERLAND. locality unknown, Schleicher 347 (CAN, mixed with S. globosus). - ROMANIA. Dist. Mures: Calimani Mts., Mt. Pietrosu, 1935 Cretzoiu (FH). - ENGLAND. CORNWALL: Bodmin Moar, 1939 Lamb 861 (CAN). - SCOTLAND. ARGYLL: Ben Arthur, 1938 Hunter (FH). - FAROES. Dist. Epsturoy: Sigatindur, Hansen 210 (TNS).

Chemotype II (Sphaerophorin)

Exsiccati seen.--Räs. Kuop. 1047 (MSC); Reich. & Schub. 375 (MICH); Schaer. 15 (FH-Tuck. 3752); Tuck. 99 (MICH).

Specimens seen.--NEW HAMPSHIRE. White Mts. 1838 Tuckerman (FH-Tuck. 3740). - NEWFOUNDLAND. Avalon-Salmonier line, Green 5979 (CAN). - LABRADOR. Settler's Hut, Gardner 140 (MICH). - QUEBEC. Matane, Mt. Blanc, Gallo 3515 (CAN). - ALASKA. Romanzoff Mts., 1951 Spetzman (MICH); St. Paul I., Schallert s.n. (MSC). - SWEDEN. locality unknown, coll. unknown (BM-Linnaean Herb. 1273-262). - NORWAY. HORDALAND: Maursat i Lysendal, 1907 Havaas (DUKE), near Granvin, 1906 Havaas (US).

Chemotype III (Sphaerophorin and squamatic acid)

Exsiccati seen.--Fellm. 21 (FH); Flor. Hung. 112 (MSC); Lojk. Univ. 208 (MICH); Räs. Hels. 147, 537 (MSC); Räs. Kuop. 923, 1024 (MSC); Rel. Far. 463 (MICH); Thoms. 31 (MSC, DUKE).

Specimens seen.--NEW HAMPSHIRE. White Mts., coll. unknown (FH), 1862 coll. unknown (FH), 1849 Oakes (FH-Tuck. 3740), Farlow 634 (FH), 1863 Mann (FH); Crawford Path, 18 June 1882 Faxon (MSC, MICH), 5 June 1882 FAXON (FH); COOS CO.: Mt. Washington, coll. unknown (FH), Aug. 1882 coll. unknown (FH, MSC), July 1886 & Aug. 1896 coll. unknown (FH), Aug. 1894 Farlow (MICH, MSC), Sept. 1904 Merrill (MICH, US, FH), Imshaug 26638 (MSC), Macfarlane & Taylor 1951 (MICH), 1949 (MICH, US), Wong 54 (CAN), Tuckerman Ravine, Aug. 1889 coll. unknown (FH), Imshaug 26684 (MSC). - MAINE. PISCATAQUIS CO.: Mt. Katahdin, Allard 5166 (MSC). - NOVA SCOTIA. Peggys Cove, Taylor 1425 (MSC). - NEWFOUNDLAND. John T. Cheeseman Prov. Park, near Port aux Basques, Taylor 1712 (MSC). - MIQUELON IS., I. St. Pierre, 1943 Gallo (MSC), Paturel 3034 (MSC). - QUEBEC. Matane, Mt. Blanc, Gallo 3052, 3079, 3067 (MSC); Gaspe, Mt. Dunraven, Tabletop Mts., Fernald, Dodge, & Smith 2618 (MICH); Great Whale River, Brisson & Forest 20336 (CAN), near Sandy Point, Kucyniak 770 (CAN, DUKE); Seal Lake, Ungava, Lapage & Dutilly 9929 (MICH); Chukotat River, Blouin 39 (CAN); Lake Payne, Legault & Brisson 8182 (CAN); McGill Lake, Polunin 17054, 17053b (MICH); Ungava, Mollie T. Lake, Harper 3749 (CAN). - MANITOBA. Churchill, Thomson 3696 (CAN); coast from Churchill to Cape Merry, Crum & Schofield 6648, 6519 (CAN, MICH). - NORTHWEST TERRITORIES. locality unknown, Steere 12994 (MICH); KEEWATIN DIST.: Southampton I., Salmon Pond, Parker SP-70-230C, SP-70-219 (CAN); MACKENZIE DIST.: Great Slave Lake, Fort Reliance, Thomson & Larsen 11044 (CAN), Coppermine, Thomson & Larsen 12978 (CAN); FRANKLIN DIST.: Baffin I.: Clyde Fiord, Hale 230 (CAN, F), Lake Harbor, Polunin 2295a-30 (FH), Pangnirtung, Polunin 2611a-26 (MICH), Frobisher Bay, 1950 Hale (CAN), Aiken 8B (CAN), Dutch Polar Station, Kungovik Fiord, Soper 153 (CAN); Axel Heiberg I., head of Expedition Fiord, Kuc L-31 (CAN). - ALASKA. vicinity of Juneau, Mt. Roberts Trail, Imshaug 28179 (MSC); White Pass, NE of Skagway, 1899 Trelease (MSC); Mt. Eielson, Mt. McKinley Nat'l. Park, Weber & Viereck S 7062 (FH, CAN, MSC); Upper Salcha River, Johnson 45 (CAN); Cape Nome, 1899 Setchell (MSC, FH); Okpilak Lake near Mt. Michelson, Thomson & Shushan 9583 (MSC). -

SAKHALIN. Mt. Suzuya, 1932 Fujikawa (TNS). - JAPAN. HOKKAIDO. I. Riishiri, Koidzumi 45714 (TNS), Okada s.n. (TNS); Mt. Daisetsue, 14 July 1936 Sato (MSC, FH), 25 July 1937, 26 July 1937 Asahina (TNS), 10 Aug. 1932, 31 July 1935 Fujikawa (TNS), Koidzumi 71838 (TNS); Mt. Ashibetsu, 1935 Asahina (TNS); HONSHU. Tochigi Pref.: Nikko, 1924 Asahina (TNS); Toyama Pref.: Mt. Tateyama, Kurokawa 50046, 56451 (TNS), 1927 Asahina (TNS); Noshijima 131, 154 (TNS), Mt. Tsurugi-dake, Kurokawa 56431 (TNS), Mt. Jonodake, 1936 Asahina (TNS), Mt. Yakushi, 1936 Asahina (TNS); Yamanashi Pref.: Sensui Pass, 1937 Asahina (TNS), Mt. Kimpo, Kurokawa 521161 (TNS), Mt. Komagatake, Koidzumi 102286 (TNS); Nagano Pref.: Mt. Nishikoma, 1926 Asahina (TNS), Mt. Norikura, 1939 Asahina (TNS), Mt. Yatsuga-dake, 1926 Asahina (TNS), Mt. Noguchigoro, Kurokawa 520331 (TNS), Mt. Akaiwadake, Kurokawa 520411 (TNS), Mt. Tadeshina, Kurokawa 51770 (TNS), Mt. Iwodake, 1926 Okada (TNS), Mt. Tengudake, Kurokawa 58215 (TNS), Mt. Kimpu, Kurokawa 65201, 520203 (TNS), Sensui Pass, Koidzumi 71485, 71486 (TNS), Mt. Shirouma, 1937 Sato (MSC); Fukushima Pref.: Mt. Iide, Iishia 5 (US); Niigata Pref.: Mt. Iide, Iishiba (US), 1910 Yasuda (TNS). SHIKOKU. Ehime Pref.: Mt. Ishizuchi, 1933 Fujikawa (TNS). - BURMA. locality unknown 1924-25 Forrest (US). - U.S.S.R. Kamchatka, 1908 coll. unknown (US); Arakamchechen I., Bering Straits, Wright s.n. (FH); Florae Rossiae, Elenkin s.n. (FH). - FINLAND. SW Toskalharji, 1955 Huuskonen (CAN, MSC). - SWEDEN. locality unknown, 1928 Ericksen (MSC); VÄSTERBOTTEN: Lycksele, Umfors, 1924 Magnusson (FH); UPPSALA: Laosbybackar, 1861 Zetterstedt (MSC), Högbyhatt, R. Santesson 12788 (MSC); ÖREBRO: Närke, Svennevad, 27 June 1952 Kjellmert (MSC). - NORWAY. Boris Gleb[?], 1906 Havaas (DUKE). - GERMANY. Bavaria, Fichtel Gebirge, coll. unknown (FH), Laurer s.n. (MICH). - FRANCE. HERAULT: Massif du Caroux, 1908 Crozals (MSC); - MOSELLE: near the Saare River [?], 1907 Crozals (MSC); HAUTE-SAVOIE: Vallorcine, 1906 Crozals (MSC). - CZECHOSLOVAKIA. Tatra Mts., coll. unknown (MSC). - SCOTLAND. ARGYLL: North Port Sonachan, Loch Awe, Lamb 916 (CAN). - NOVA ZEMLYA. Matotchkin Shar: Pomorskaya, 7 July 1921 Lynge (FH). - GREENLAND. Godhavn, Disko I., Erlanson 2737, 2780 (MICH): Kangedluarssuk, Hansen 1679 (TNS), 1684 (MICH).

Chemotype IV (Sphaerophorin, squamtic acid, and hypothamnolic acid)

Exsiccati seen.--Claud. 220 (FH); Harm. Loth. 149 (MSC); Hepp Fl. Eur. 664 (FH); Mig. 20 (MICH, MSC); Moug. 263 (FH-Tayl. 153, MSC); Räs. Kuop. 441 (MSC); Vezda Boh. 214, 277 (DUKE).

Specimens seen.--NEW HAMPSHIRE. COOS CO.: Mt. Washington, Aug. 1894 Farlow (FH), Sept. 1904 Merrill (FH), Macfarlane & Taylor 1950 (MICH). - MAINE. PISCATAQUITS CO.: Mt. Katahdin, Merrill 7 (FH), 1924 Nortan (FH). - QUEBEC. Gulf of Richmond, Lapage & Dutilly 6694 (MICH). - ALASKA. Unalaska I., 1932 Eyerdam (MICH, FH). - U.S.S.R. Prov. Archangel, 1892 Tanfiliev (FH). - FINLAND. Kimito, Vreta, 25 March 1949 Hallström (MICH), 15 Oct. 1949 Hallström (MSC, DUKE); Ropinsalmi, 1966 Roivainen (MSC). - SWEDEN. Dalsland, 1918 Berström (FH); HALLAND: Vallda, Välas, 1925 Stenholm (FH); GÖTEBORG OCH BOHUS: Göteborg, 1917 Stenholm (DUKE). - NORWAY. HORDALAND: Voss, 1927 Havaas (DUKE), Maursat i Lysendal, 1907 Havaas (DUKE), Maursat på Hordangervidda, Havaas s.n. (DUKE); SOGN OG FJORDANE: Vadheim i Sogn, 1900 Havaas (DUKE); FINMARK: Hammerfest, 1906 Havaas (DUKE). - GERMANY. Bavaria, Fichtel

Gebirge, coll. unknown (FH-Tayl. 147). - FRANCE. PUY-DE-DOME: locality unknown, 1886 Parrique (FH). - CZECHOSLOVAKIA. Carpathia Mts., 1889 Greschik (FH). - ENGLAND. CORNWALL: Bodmin Moar, 1939 Lamb (CAN); WESTMORLAND: locality unknown, 1903 Wilson & Wheldon (FH); CUMBERLAND: locality unknown, 1910 West 70 (FH). - SCOTLAND. AYR: Black Craig [Hill], McAndrew s.n. (MICH); ABERDEEN: Braemor, Lam 6799 (MICH). FAROES. Dist. Sudbury: Porkeri, Hansen 217 (MICH). - ICELAND. Grafningur Dist.: Nasjavellir Farm, Kristinsson 22172 (CAN); Cape Skagi, Matklettshaedir Hills, Kristinsson 13335 (CAN).

3. Sphaerophorus globosus (Huds.) Vain.

Result Voyage S. Y. Belgica, Botan. 35. 1903. Lichen globosus Huds. Flora Anglica 460. 1762. Original material: See discussion in nomenclatural remarks.

Sphaerophoron globiferum var. gracile Müll. Arg. Flora 66: 354. 1883. Sphaerophorus globosus var. gracilis (Müll. Arg.) Zahlbr. Cat. Lich. Univ. 1: 693. 1922. Type: Mexico, Guadeloupe I., on trees, 1875 E. Palmer (US, holotype; FH, MSC, isotype).

Sphaerophoron globiferum var. polycladum Müll. Arg. Botan. Jahrbuch. 4: 53. 1883. Sphaerophoron polycladum (Müll. Arg.) Müll. Arg. Flora 71: 17. 1888. Type: Chile, Punta Arenas, Straits of Magellan, Lechler 992 (PC, holotype; BM, isotype).

Sphaerophoron divergens Stirt. Trans. & Proc. Bot. Soc. Edinburgh 14: 357. 1883. Type: Canada, Newfoundland, A. Gray s.n. (BM, holotype).

Sphaerophoron globiferum var. _versicolor_ Müll. Arg. Mission Scientif. Cap Horn 5: 145. 1888. _Sphaerophorus globosus_ var. _versicolor_ (Müll. Arg.) Zahlbr. Cat. Lich. Univ. 1: 693. 1922. Type: Chile, I. Horn, Tierra del Fuego, _Hariot 27_ (PC, holotype; PC, isotype).

Sphaerophorus globiferus var. _palmanus_ J. Stein. Oesterr. Bot. Z. 54: 447. 1904. _Sphaerophorus globosus_ var. _palmanus_ (J. Stein.) Zahlbr. Cat. Lich. Univ. 1: 692. 1922. Type: Canary Is., LaPalma Cumbre nueva in ramis _Ericae arborae_, _J. Bornmüller 3246_ (BM, holotype).

Sphaerophorus tuckermanii Räs. Ann. Missouri Bot. Gard. 20: 20. 1933. Type: Canada, British Columbia, Hazelton, 1931 _Kujala_ (MSC, holotype).

Sphaerophorus turfaceous Asah. ex Mituno, J. Jap. Bot. 14: 665. 1938. Type: Japan, Hokkaido, Mt. Daisetsu, 10 Aug. 1932 _Fujikawa_ (TNS, lectotype).

Nomenclatural Remarks

As it is not known upon which specimen or illustration Hudson (1762) based his description for _Lichen globosus_, a specimen must be selected as the lectotype. If Hudson based his description on a specimen from his personal herbarium we can assume that it was destroyed in a fire in 1783 (Dixon, 1959). As Dixon (1963) relates, Hudson sometimes based his descriptions on previous publications and illustrations and it seems possible that the description of _L. globosus_ may have been based on Dillenius's illustration of

"Coralloides cupressiforme, capitulis globosis," Dill. Musc. 117. t. 17. f. 35., which is the only illustration cited in the original description by Hudson. The Dillenian illustration shows three thalli and one of these, I feel, should be designated as the lectotype. According to Crombie (1880) there are three thalli presumably the ones illustrated in Historia Muscorum (Dillaneus, 1741). Since I have not seen the material and in view of the chemical variation within the species, a lectotype is not designated at the present time.

Sphaerophoron globiferum var. polycladum Müll. Arg. is based on a heavily branched specimen. Sphaerophrin was found to be its only chemical constituent.

Sphaerophoron divergens Stirt. was described as a new species on its KOH + yellow medullary reaction. This reaction, due to the presence of thamnolic acid, is not considered worthy of taxonomic recognition.

Sphaerophoron globiferum var. versicolor Müll. Arg. was based on a light colored specimen of S. globosus. The lichen substances found in the specimen include sphaerophorin and thamnolic acid.

Sphaerophorus globiferus var. palmanus J. Stein. according to the original description has a slightly different growth habit than the normal S. globosus, but is considered of no taxonomic significance. The only lichen substance found in the type specimen was sphaerophorin.

Sphaerophorus tuckermanii Räs. is a sparsely branched specimen of S. globosus. It was found to contain only sphaerophorin.

Sphaerophorus turfaceus Asah. is lectotypified as Asahina did not designate a type specimen in his original publication. Material from the National Science Museum (TNS) which has been annotated as type material, probably by Asahina, is selected as the lectotype. It was found to contain only sphaerophorin.

Description

Thallus caespitose, variable in size, forming small to fairly large cushions (up to 15 cm across) on rocks and on trunks and branches of trees or spreading over large areas on the soil, up to 1 meter in width. Primary branches erect to decumbent, occasionally becoming pendent on the branches and trunks of trees, to 8 cm in length, 0.8-1.5 (2.0) mm in diameter, terete. Secondary branching variable from sparse to heavily coralloid, irregular to anisotomic dichotomous, interlacing with each other. Surface nitid, brownish to grayish green, occasionally transversely annulate-cracked in some specimens with frequent coralloid or phyllocladial branchlets occurring singly or in fasciculate groups. Cortex 90-130 μ thick, composed of thick-walled, gelatinized, fused hyphae intricated in various directions, covered by a thin (2-3 μ) colorless epicortex. Algae-medullary layer, 20-40 μ thick, usually completely surrounding the central medullary layer, but occasionally in larger branches may be absent on the lower side; algae protococcoid, spherical, 8.0-10.5 μ in diameter. Central medulla composed of thick-walled, hyaline, longitudinally arranged hyphae, 4.5-7.0 μ in diameter, generally distinct from each other and loosely intricated. Apothecia common, subglobose to globose, terminal, 1.0-3.5 mm across. Mazaedium oriented apically, becoming exposed at an early stage of development by the irregular apical rupturing of the enclosing recptacle, when mature, globose, black, partially surrounded by the receptacle. Asci cylindric, near maturity, 45-60 X 5-8 μ, containing 8 spores arranged in a row. Spores spherical to broadly ellipsoid, greenish becoming dark blue when mature, 8-10 μ in diameter. Pycnidia occasional, forming at the terminal ends of the branches; microconidia rod-shaped, colorless, 4-5 X 1-1.5 μ.

Medullary reactions.--PD - or PD + yellow, KOH - or KOH yellow or occasionally violet, KC -, C -, I +.

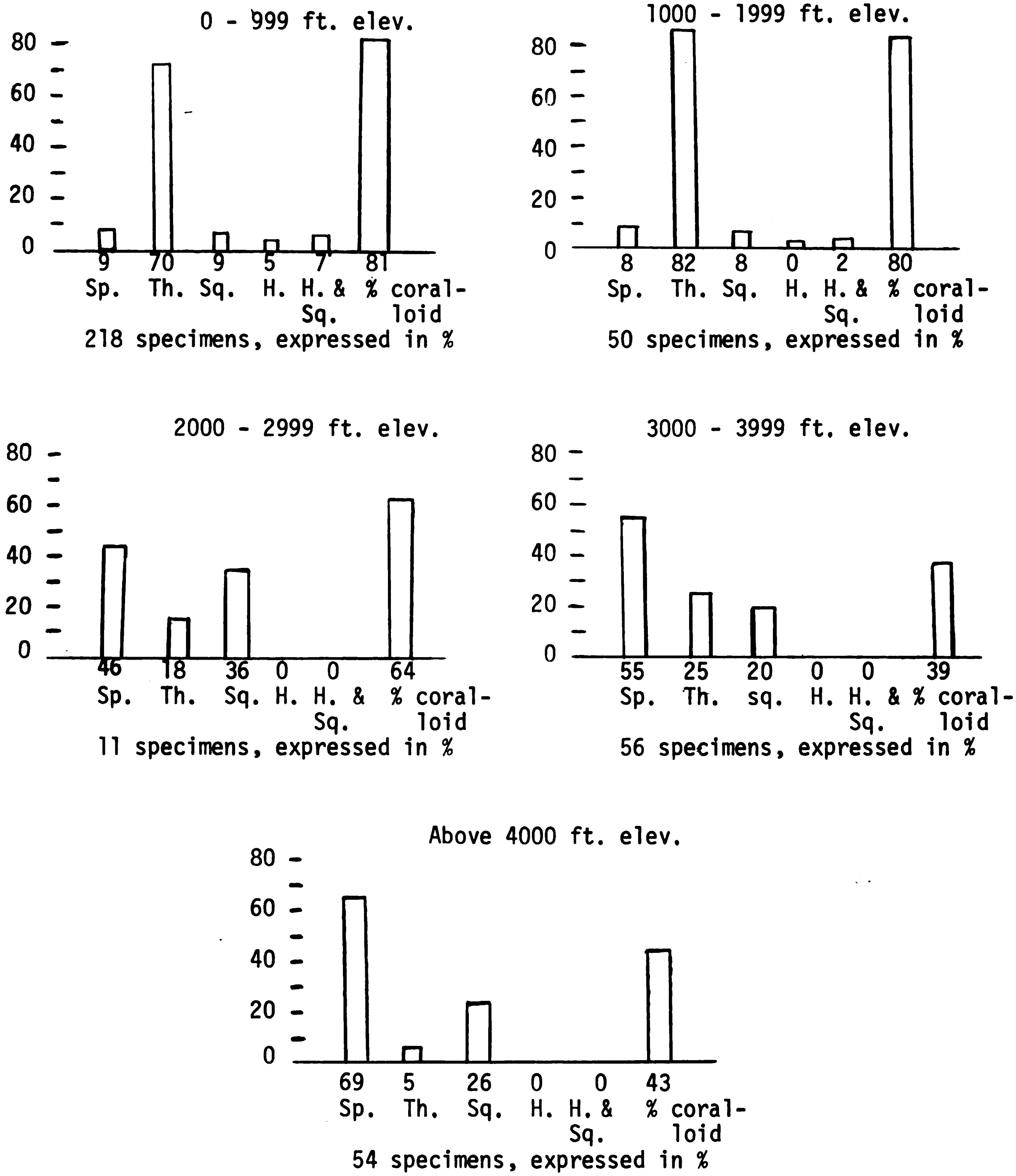
Constituents.--Sphaerophorin, thamnolic acid, squamatic acid, and hypothamnolic acid. Upon examination of over 1240 specimens of S. globosus, the taxon was found to consist of six chemotypes. These same six chemotypes were found by Rehm (1971) in her survey of North American and European specimens of this species. She also briefly discussed differences in the geographical distribution of the various chemotypes. My study has shown all six strains to be present in both North America and Europe but with distinct differences in their distribution. The European specimens have a relatively high percentage of specimens with hypothamnolic acid while in North America, chemotype II, with thamnolic acid is most common, especially along the Pacific Coast. As yet no plausible explanation has been made for the variable, but somewhat predictable differences in the distribution of various chemical strains or chemotype. Sato (1965) discusses the distribution of two chemical strains in *Thamnolia* and Culberson (1967) presents the distribution of the various chemical strains in the *Ramalina siliquosa* complex.

To determine what factor or factors might influence the distribution of a chemotype in *S. globosus*, specimens from four diverse geographic areas in British Columbia were analyzed (see Table 6). Randomly selected thalli were utilized for chemical and morphological study. A general correlation with elevation and chemical constituents were found and some related differences in morphogy were also noticed, but not consistantly enough to enable one to predict the chemical constituents of a specimen by its appearance. Although only a small sample was studied from each locality, no significance could be attached to substrate differences. The results showed that most specimens containing thamnolic acid occurred at low elevations, but above 2000 ft. a relatively high percentage of specimens contained sphaerophorin alone or with squamatic acid. Hypothamnolic acid was most often produced in specimens from lower elevations, becoming especially abundant in highly oceanic areas such as the Queen Charlotte Islands, where it was found to occur with sphaerophorin or with sphaerophorin and squamatic acid in over 39% of the specimens studied. Table 7 analyzes the distribution of each chemotype in British Columbia based on a study of 389 specimens. This study helps to substantiate

Table 6. The distribution of chemotypes of _S. globosus_ studied from four localities in British Columbia.

Substrate	Elevation	No. of Specimens	Chemotype I (sphaerophorin)	Chemotype II (thamnolic)	Chemotype III (squamatic)	Chemotype IV (hypothamnolic)	Chemotype V (hypothamnolic and squamatic)
Abies (KEO 2576)	4500 ft.	23	68%	-	22%	-	-
Tsuga (KEO 2575)	4500 ft.	11	72%	-	28%	-	-
Pseudotsuga (KEO 1798)	3400 ft.	26	65%	12%	23%	-	-
Tsuga (KEO 1138)	1800 ft.	20	-	100%	-	-	-
Pinus (KEO 2043)	sea level	20	-	95%	-	-	5%
rock (KEO 2058)	sea level	12	-	92%	-	8%	-

Text Figure 4. The distribution of five chemotypes of S. globosus from British Columbia with reference to elevation. (Sp. = Sphaerophorin; Th. = Thamnolic acid; Sq. = Squamatic acid; H. = Hypothamnolic acid).



the distribution of the various chemotypes correlating them with elevation.

As previously mentioned, the chemotype is often associated with a particular thallus morphology. Specimens from lower elevations tend to have a more coralloid nature and as higher elevations are reached the specimens become rather sparsely branched and elongated. It is also interesting to note that of the 266 coralloid specimens examined only 34% were found to be fertile while 75% of the 123 noncoralloid specimens produced apothecia. This might suggest the importance of coralloid phyllocladia as vegetative propagules.

Chemotype I

Sphaerophorin (see Figure 45). This chemotype is most common in the arctic and alpine regions of North America. In the Canadian Northwest Territories over 86% of the 43 specimens are of this type. In British Columbia specimens with only sphaerophorin had a relatively higher number of individuals at elevation above 2000 ft.

Chemotype II

Sphaerophorin and thamnolic acid (see Figure 46). This chemotype seems to occur in more moderating oceanic climates being the most common strain along the North American pacific coast, but interestingly has not been found in specimens from Japan. All specimens from the Falkland Islands in the southern hemisphere contained sphaerophorin and thamnolic acid. In British Columbia this chemotype was often found in specimens exhibiting a coralloid morphology, but this condition is not always predictable. The specimens from the Falkland Islands and from southern South America are found either on soil or occasionally on rock and all have a noncoralloid nature.

Chemotype III

Sphaerophorin and squamatic acid (see Figure 47). This chemotype is totally absent from the southern hemisphere, but occurs throughout the range of the species in the northern hemisphere. It seems to be most common in Alaska and in British Columbia, usually growing at fairly high altitudes where environmental conditions are more rigorous.

Chemotype IV

Sphaerophorin and hypothamnolic acid (see Figure 48). Specimens belonging to this chemotype are commonly found in the most moderating oceanic conditions. It is fairly rare, with only 2% of the specimens being of this strain.

Chemotype V

Sphaerophorin, hypothamnolic acid, and squamatic acid (see Figure 49). This chemotype is found in 5% of all specimens examined. Again, as has been found in other species or chemotypes, the distribution is this chemotype is not random. For instance, in the Queen Charlotte Islands nearly one-third of all specimens were of this chemotype.

Chemotype VI

Sphaerophorin, squamatic acid and thamnolic acid (see Figure 50). The substances for this chemotype have been found to be present is only 2% of all specimens of S. globosus. Its occurrence seems to be random, but further study might show some more specific distributional patterns.

Discussion

Sphaerophorus globosus has a temperate circumboreal generally oceanic distribution with outliers in the southern hemisphere. Other lichens with similar distributions include Stereocaulon tomentosum, Alectoria nigricans, Cetraria nivalis, and Cetraria islandica. In the Pacific Northwest this species commonly occurs on conifers, rarely on soil or rock, but in southern South America I have no record of nor have I seen it growing on trees; instead, it is a common soil or rock lichen forming large isolated patches similar to the cushions formed by S. tener. It also occurs on soil in the North American tundra and apparently occurs on soil and on trees in Japan.

Material Examined

Chemotype I (Sphaerophorin)

Exsiccati seen.--Anzi Lang. 421 (FH-Tuck. 3748); Hav. Nor. 98 (DUKE); Macoun II. 71 (MSC, FH, BM MICH); Malme Austro. 428 (H, MSC); Merr. 56 (FH); Räs Kuop. 1072 (MSC); Rel. Tuck. 137 (DUKE, MICH. MSC, FH); Thoms. 4 (MSC, DUKE); Tobole. 131 (DUKE); Tuck. 50 (MICH, FH).

Specimens seen.--NEW HAMPSHIRE. White Mt., 1862 coll. unknown (FH), coll. unknown (DUKE), Mann s.n. (FH), 1838 Tuckerman (FH-Tuck. 3741), 1844 Tuckerman (FH-Tuck. 3740, mixed with S. fragilis). - NEW BRUNSWICK. ALBERT CO.: Fundy Nat'l. Park, Herring Cove, Imshaug 26535 (MSC). - NOVA SCOTIA. COLCHESTER CO.: Solmon River, Wehmeyer 1205 (MICH); GUYS CO.: Hartleys Falls, near Port Mulgrove, Prince 6484 (MICH); VICTORIA CO.: 8 mi. up Clyburn Valley from Ingonish, Lamb 7003 (CAN), 8 mi. NW of Baddeck, Lamb 6851 (FH); Cape Breten Co.; Louisburg Light, Taylor 1658 (MSC); Louisburg, Lamb 6889 (CAN). - NEWFOUNDLAND. near Trout River, Williams 2501 (CAN); Cape Bonavista, Taylor 2089 (MSC); Cape Freels, Taylor 2128 (MSC); St. Johns Bay, Eastern Point, Fernald, Long & Fogg 2256 (MSC); Highlands of St. Johns, Deep Gulch, Doctor Hill, Fernald, Long & Fogg 2272 (MSC). - MIQUELON IS.: locality unknown, coll. unknown (BM), Delamare (MSC). - LABORADOR. coast, 1898 Low (CAN); Schefferville area, Irony Mt., 1967 Heikkila & Kallio (CAN). - QUEBEC. Fort George, I. Loon, Lapage & Dutilly 6261 (CAN, MICH), 6295, 6381 (MICH); Richmond, Gulf, Lapage &

Dutilly 6608, 6645 (MICH); Cape Prince of Wales, Hudson Strait, 1884 Bell (CAN): Wakeham Bay, Polunin 1480b-20 (FH); vicinity of Gerin Mt., Viereck 730a (CAN, FH); Kallio & Heikkila 47a (CAN); N side of Leaf River, Marr 199 (CAN, FH); Leaf Lake, Marr 74 (CAN); Payne Lake, Rousseau 765 (MSC), Legault & Brisson 8036 (CAN); Chukotat River, Rusty Lake, Blouin 22 (CAN); Hudson Bay, Great Whale River, Thompson 14 (CAN), Brisson & Forest 20295, 20332 (CAN); Goose Bay, Kucyniak & Tuomikoski 356 (MSC), 338 (CAN); Long Point, James Bay, Kucyniak & Tuomikoski 185 (CAN); Anticorti, 1883 Macoun (CAN); Salmon River, Cape Jones, Kucyniak & Tuomikoski 434 (CAN); Mt. Albert, Gaspé, 1882 Macoun (CAN); Hudson Bay, Digges I., 1884 Bell (CAN). - ONTARIO. KENORA DIST.: Cape Henrietta Maria, Cowell 1294 (CAN), Courtin & Bisset 5 (CAN); Cloudy Lake ridges, Polar Bear Park, M. Webber 1877 (CAN). - MANITOBA. Churchill, Beckett M-12 (CAN), 18 (CAN, MICH), Gillis 3351 (MSC), Gillet 1636 2809, 2871, 1877E (MICH), Thomson 3710, 3760, 3694, 3699 (CAN), Irvine 111 (CAN); Christmas Lake, E of Churchill, Irvine 127 (CAN); coast from Churchill to Cape Merry, Crum & Schofield 6518 (CAN, MICH), 6653, 6643 (CAN). - NORTHWEST TERRITORIES. locality unknown, Steere 12934, 12995 (MICH); KEEWATIN DIST.; Bencas I., Copeland 75-1028 (CAN); S of Ennadai, Thomson & Larsen 11522 (CAN); S end of Dubawnt Lake, Thomson, Larsen, & Foote 14132 (CAN); N shore, Aberdeen Lake Rossbach 6671 (CAN); Southampton I., Coral Harbor, Brown 100 (CAN), Bear's Cove Point, Brown 117-920, 159-829 (CAN), Salmon Pond, Parker SP-70-211, SP-70-42 (CAN); Cape Fullerton, 1957 Beckett (CAN); MACKENZIE DIST.: Artillery Lake, Rat Lodge, Thomson & Larsen 12594 (CAN); Coppermine, Thomson & Larsen 12432, 12394 (CAN); FRANKLIN DIST.: Baffin I.: Westbourne Bay, Lee 2539P, 2540B (CAN), Blacklead I., Cumberland Gulf, Soper 306 (CAN), Baffin Sound, 1904 Low (FH), Frobisher Bay, Hale 454 (CAN), Weber S24008 (CAN), Thomson 13201 (CAN), Cape Dorchester, Presidente 1718 (CAN); head of Clyde River Fiord, Hale 231 (DUKE, CAN), 232 (CAN), Clyde River, Dutilly 9365 (MICH); Cape Searle, Hale 395 (CAN), Barnes Ice Cap, Hale 465 (CAN), Pond Inlet, Hale 453 (CAN); Axel Heiberg I., White Glacier, Expedition Fiord, Kuc L-29, L-40, L-57 (CAN); Meighen I., Kuc AA-12 (CAN). - YUKON. King Solomon Dome, SE of Dawson, Calder & Billard 3483 (MICH); the "Dome," Klondike Divide, 1902 Macoun (FH, CAN). - ALASKA. Russian America, 1868 Kellogg (FH); Windham Bay, Culbertson 122 (FH); vicinity of Juneau, Herbert Glacier, Imshaug 28399 (MSC), Montana Creek Roak, Imshaug 28625, 28609A (MSC); Mt. Juneau, Imshaug 28769, 28715 (MSC), Mt. Roberts Trail, Imshaug 28247, 28277, 28192 (MSC), Auke Lake, Imshaug 28507 (MSC); Skagway, 1902 Macoun (CAN), Cowles 1026 (MSC); Point Gustavus, Coville & Kearney 2060, 782 (MSC); Yakutat Bay, 1909 Beckett (FH); Cordova Sheridan Glacier, Anloit 1505, 1519 (DUKE); Orca, Hinchinbrook I., 4 Aug. 1937 Norberg (FH); Knight I., Thum Bay, Prince William Sound, Eyerdam 293 (FH); Neknek, Lepage 22657 (MICH); Eagle Pass, Steese Highway, 1962 Johnson (DUKE); Mt. Eielson, Mt. McKinley Nat'l. Park, Webber & Viereck S7086 (MSC, FH, DUKE); St. Michael, 1899 Setchell (FH); Teller, Palmer 528 (FH); between Port Clarence Bay and Teller, 1913 Johansen (FH); E of Cape Lisburne, Pitmegea River, Cantlon & Gillis 57-145B, 57-333A, 57-313, 57-183, 57-2415 (MSC); E of Wainwright, Stenson 24, 31 (MICH); Point Barrow, Elson Lagoon, 1962 Johnson (DUKE); Barrow, Cantlon & Gillis 57-2480 (MSC); E of Colville River, 15 mi. from delta, Borman, Cantlon, & Rebuck 1345 (MSC); Wiseman, Jordal 1955 (MICH); Umiat, coll. unknown (MSC), Borman, Cantlon, & Rebuck 1046, 1052, 1171, 1234 (MSC), Bliss 2061, 1 (DUKE); E of Okpilak Lake, Cantlon & Malcolm 58-637, 58-404 (MSC); Okpilak Lake, Cantlon & Malcolm 58-674 (MSC); ENE of Okpilak Lake, Cantlon & Gillis 57-1866 (MSC); Jago River, S of Jago Lake, Cantlon & Gillis 57-1503, 57-1482, 57-1494 (MSC); 10 mi. N of Jago Lake on Jago River, Cantlon & Gillis 57-1686 (MSC); Jago River terrace, Cantlon & Gillis 57-1001, 57-998 (MSC); 1.2 mi. N of Jago Lake, Cantlon & Gillis 57-1227 (MSC); Jago Lake, Cantlon & Gillis 57-519 (MSC); Romanzoff Mts., 1951 Spetzman (MICH); St. Lawrence I., Trelease 1210, 1285 (MSC), 13 July 1899 Trelease (DUKE); Hall I., Trelease 1213 (MSC); St. George I., 1914 Parker (FH); Aleutian Is., Bank RD-36a (MICH); Unalaska, Eyerdam s.n. (MICH, FH), 24 May 1932 Eyerdam (MSC, MICH); Kagamil I., Bank 1002 (MICH); Amlia I., 10 July 1932 Eyerdam (FH); Atka I., Eyerdam s.n. (MICH), 1 July 1932 Eyerdam (FH, MICH); Great Sitkin I., Bank 4069 (MICH); Tanaga I., Miller 1117 (MICH); Amchitka I., Reich & McCann 48a, 132, 150, 340, 368 (CAN); Attu I., Howard 936 (US), Jordahl & Miller 3183, 3157 (MICH). - BRITISH COLUMBIA. Johnstons Strait, 1885 Dawson (CAN); Brackendale, 1916 Macoun (FH); Black Tusk Area, Garibaldi Prov. Park, Ohlsson 620, 622, 628 (MSC); Paul Ridge, Round Mt., Garibaldi Prov. Park, Schofield 14471 (CAN, DUKE); N of Alta Lake, Garibaldi Prov. Park, Ohlsson 669 (MSC); mountain 15 mi. NE of Stillwater, Ohlsson 969 (MSC); Mt. Claque, Ohlsson 2752 (MSC); Minette Bay, N end of Kitimat Arm, Ohlsson 2654 (MSC); 10 mi. S of Furlong Bay Prov. Campground, Ohlsson 2705 (MSC); 8 mi. S of Furlong Bay Prov. Campground, Ohlsson 2406, 2404 (MSC); Lakelse, Ohlsson 2584 (MSC); pass between Mt. Thornhill and Mt. Attree, E. of Terrace, Ohlsson 2572, 2576 (MSC); Bornite Mt., 10 mi. E of Terrace, Ohlsson 2717 (MSC); 21 mi. E of Terrace, Highway 16, Ohlsson 2833, 2843 (MSC); Hazelton, 1931 Kujala (MSC); VANCOUVER I.: locality unknown, coll. unknown 255 (CAN), Hasting's, 1889 Macoun 49 (CAN), Victoria 1887 Macoun (FH), near fourth Nanaimo Lake, 1950 Krajina, Spilsbury, & Szczawinski (DUKE), Blackjack Mt., Nanaimo River Valley, 27 June 1950 Krajina, Spilsbury, & Szczawinski (DUKE), Mt. Becher, W of Courenay, Ohlsson 1707A (MSC), Forbidden Plateau, W of Courtenay, Ohlsson 1789, 1790, 1791, 1795, 1798, 1801, 1802 (MSC), Mt. Cain, N of Schoen Lake, Ohlsson 1211, 1265, 1569 (MSC), Schoen Lake, Ohlsson 1304, 1287 (MSC), Nimpkish River Campground, 5 mi. SE of Port McNeill, Ohlsson 1525 (MSC); Thurlow I., Macoun 91 (CAN); QUEEN CHARLOTTE IS. Moreby I.: Tokakia Lake, Brodo 10962 (CAN), Barry Inlet, Brodo 14198 (CAN), upper Victoria Lake, Brodo 12270 (CAN); Tasu Mt., Brodo 14262 (CAN): Graham I.: 6.6 mi. SE of Port Clements, Brodo 9777 (CAN), Langara I., Brodo 10629 (CAN), Skidegate, 1910 Spreadborough (CAN). - WASHINGTON. Cascade Mts., 1925 Grant (MICH); CLALLAM CO.: Olympic Hot Springs, 1922 Braun (DUKE), Soleduck Hot Springs, Brodo 13234A (CAN), Weir 12732 (FH), Elwha River, Smith 2304 (MICH), Elwha Valley, Baad 17a (MICH); Cape Flattery, 1969 Culberson (DUKE); GRAYS HARBOR CO.: Westport, 1951 Herre (MICH); ISLAND CO.: 13 mi. N of Oak Harbor, Whidbey I., Brodo 13051 (DUKE), Langley, 1923 Grant (DUKE); PIERCE CO.: Eagle Peak trail, Imshaug 1556 (MICH), White River, Imshaug 397 (MICH), Nisqually River, Imshaug 1186 (MICH), Kotsuck Creek, Imshaug 132 (CAN), Tohoma Creek, Imshaug 1760 (MICH); WHATCOM CO.: locality unknown, 1858 Lyall (FH), Mt. Baker Nat'l. Forest, Tomghoi Lake trail, Brodo 13051, 13056A (CAN), Ruth Mt., Howard 1842 (FH). - OREGON. CURRY CO.: Cape Blanco near Port Oxford, Imshaug 17662 (MSC). - CALIFORNIA. DEL NORTE CO.: 15 mi. E of Crescent City, Thiers 12798 (CAN). - JAPAN. HOKKAIDO: Mt. Daisetsu, 10 Aug. 1932 Fujikawa (TNS), 26 July 1937 Asahina (TNS); Mt. Tomurausi, 1 Aug. 1935 Sato (TNS). HONSHU. Toyama Pref.: Mt. Tsurugi-dake, Kurokawa 56432 (TNS); Nagano Pref.: Mt. Goryu-dake, Kurokawa 51385 (TNS), Mt. Shirouma, 1939 Asahina (TNS), Mt. Kashima-yari, Kurokawa 51437 (TNS). - U.S.S.R. Arakamchechen I., Bering Straits, Wright s.n. (BM); Kamchatka, Petropavlovsk, 1931 Kobayashi (TNS, BM); Siberia, 1927 coll. unknown (DUKE); Kolguev I., 1902 Pohle (FH). -

FINLAND. locality unknown, 1857 Th. Fries (FH-Tuck. 3749). - SWEDEN. Västergotland, 1916 Sandberg (CAN); SÖDERMANLAND: Dunker, 1891 Blomberg (DUKE); JÄMTLAND. Storlien, 1917 Vrang (US), 1909 Vrang (DUKE); JÖNKÖPING. Malmbäck, 1927 Haglund (FH). - NORWAY. TROMSO. locality unknown, 1910 Lynge (FH); FINMARK. locality unknown, Havaas s.n. (CAN); OPLAND. Dovrefjeld, Schimper s.n. (FH). - GERMANY. Mt. Lerchenköpfe, Garrigues s.n. (MICH). - CZECHOSLOVAKIA. Liberic, 1856 Zupfkuv (MSC). - CANARY IS. LA PALMA.: Bornmüller 3246 (BM). - NOVA ZEMLYA. Dal Bay, 8 June

1921 Lynge (CAN, TNS). - SPITZBERGEN. locality unknown, 20 Aug. 1926 Lynge (CAN); Bellsund, 8 Aug. 1926 Lynge (FH). - JAN MAYERN. Cape trail, Russel 541 (FH). - ICELAND. Laxardal, 1939 Palsson (MSC); Skagafjardar, Tindastoll Mt., Kristinsson 13286 (CAN). - GREENLAND. locality unknown, Giseke s.n. (FH-Tayl. 151); W. coast, up to 500 mi. of North Pole, 1938 Miller (MSC); Torssukatak, Hansen 1723 (TNS); Igaliko Fjord, Hansen 1718 (TNS); Northumberland I., Stein 23 (US); vicinity of Thule, 1956 Marr (CAN); King Oscars Fjord, Antartichamna, 1930 Scholander (MSC, FH). -

CHILE. PROV. MAGALLANES. Straits of Magellan, 1767 Commerson (PC); Punta Sta. Ana, 1969 Fehlmann (MSC), Cape Horn, coll. unknown (FH, FH-Tuck. 3750), Hooker s.n. (BM); Cabo Spencer, Hermite I., 1842 Hooker (BM), Punta Arenas, Lechler 992 (PC-Hue, PC, BM), 7 Feb. 1867 Cunningham (BM), Puerto Cutter, Monte Condor, Imshaug 39465, 39464 (MSC), Fuerte Bulnes, Imshaug 38684, 38693B (MSC), B. Plüschow, 1939 Roivainen (H). - ARGENTINA. patagonia, 1896-97 Hatcher (MSC), Prov. Santa Cruz: Cerro Mayo, James 1707 (BM); I. Grande: Rio Grande, Mexia 7963A (F), 7962B, 7962C (FH, BM), 1896 Dusén (FH), 2 km. S of Estancia Rio Ewan, Imshaug 54239B (MSC), Lago Hantu, Imshaug 54394, 54387 (MSC), Lago Fagnano, 1929 Roivainen (H), Paso Garibaldi, Schuster 58321 (FH), Imshaug 54820 (MSC), E side of Paso Garibaldi, Sierra Lucas Bridges, Imshaug 55470 (MSC), Mt. to E of Mt. Olivia, Imshaug 55567, 55621 (MSC), Ushuaia, Punta Acantilada, Roivainen 1632 (MSC), Ushuaia, Baliza, Roivainen 1202, 1218 (MSC), W side of B. Lapataia, Imshaug 55031 (MSC). - SOUTH ORKNEYS. Signy I., Observation Bluff, 1965 Price (BM).

Chemotype II (Sphaerophorin and thamnolic acid)

Exsiccati seen.--Cum. I. 148 (MSC, MICH, DUKE, BM, FH), II. 257 (MICH); Fr. 60 (FH-Tayl. 156, FH-Tuck. 3749); Macoun I. 200 (DUKE, MSC, MICH, FH), Merr. 56 (DUKE, MICH, BM); Mig. 72 (MICH, MSC); Moug. 262 (MSC); Rab. 234 (MICH); Rel. Far. 462 (MICH, MSC).

Specimens seen.--NEW BRUNSWICK. ALBERT CO.: Fundy Nat'l. Park, 1/2 mi. E of point Wolfe Campground, Ireland 11409 (MSC). - NOVA SCOTIA. COLCHESTER CO.: Truro, Victoria Park, Wehmeyer 1162 (MICH), Truro, 1883 Macoun (CAN); VICTORIA CO.; 8 mi. NW of Baddeck, Lamb 6851 (CAN); CAPE BRETON CO.: Main á Dieu, Lamb 6926 (CAN, MICH). - NEWFOUNDLAND. locality unknown, Green 5976 (CAN), Gray s.n. (BM), Ayre 403 (FH); Placentia, 1894 Robinson & Schrenk (FH, MICH, MSC); Salmonier, Thaxter 533 (FH), 1885 Thaxter (FH); Ironville, Placentia Bay Region, 1943 Heinze (MSC); near Brigus Junct., Fernald & Wiegand 6570 (FH, MICH, MSC); Trinity Bay, Wagborne 45 (MSC). - MIQUELON IS.: Langlade, Little Barachois, 1946 Goupilliere (MSC). - LABORADOR. Grady I., Gardner 26 (MICH). - NORTHWEST TERRITORIES. FRANKLIN DIST.: Baffin I., Pangnirtung, Polunin 2643a-21 (FH, MICH). - ALASKA. Ketchikan, Eyerdam 265 (MSC); Knight I., Thum Bay, Prince William Sound, Eyerdam 276 (MSC), 230, 281a, 280a (MICH), 234 (MICH, FH); Kodiak I., Silverwood 12 (US); St. George I., 1914 Parker (FH); St. Paul I., J. M. Macoun 58 (CAN); Attu I., Miller 287 (MICH). - BRITISH COLUMBIA. locality unknown, 8 Nov. 1913 Macoun (CAN), 26 April 1914 Macoun (CAN); Sannichtan, 3 Dec. 1913 Macoun (CAN); New Westminster, Hill

1577 (FH); Abbotsford, Hill 337 (FH); Chilliwack, Macoun 101 (FH); Hope, Brodo 7852 (CAN); Coquitlam Lake, 3 May 1904 Hill (FH, MICH); Brackendale, 1916 Macoun (FH); near Alice Lake Prov. Campground, N of Squamish, Ohlsson 428, 431, 731, 716, 712, 709, 449, 443, 438, 433, 445, 453, 483, 488 (MSC); Cheekey, Schofield 12855 (CAN); N of Cheekye, Ohlsson 494, 500 (MSC); Black Tusk Area, Garibaldi Prov. Park, Ohlsson 563 (MSC); SW of Port Mellon, Ohlsson 896, 890, 881 (MSC); Mt. Richardson, N of Sechelt, Ohlsson 750, 784, 794, 805, 819, 838, 845 (MSC); S of Earl's Cove, Brodo 8347 (CAN); mountain, 15 mi. NE of Stillwater, Ohlsson 978, 980, 998, 1003, 1004, 1006 (MSC); 19 mi. E of Bella Coola, Ohlsson 2265 (MSC); 5 mi. W of Bella Coola, Clayton Falls Creek, Ohlsson 2129 (MSC); Burke Channel, Crayden Bay, Ohlsson 2058, 2043 (MSC); N side of Burke Channel, across from Restoration Bay, Ohlsson 2071 (MSC); Namu, W end of Burke Channel, Ohlsson 2090 (MSC); Pt. Ashton, Douglas Channel, Ohlsson 2499 (MSC); Mt. Claque, Ohlsson 2752 (MSC); Minette Bay, N end of Kitimat Arm, Ohlsson 2659, 2649 (MSC); 10 mi. S of Furlong Bay Prov. Campground, Ohlsson 2701 (MSC); 8 mi. S of Furlong Bay Prov. Campground, Ohlsson 2404 (MSC); Lakelse, Schofield 20859 (CAN); Bornite Mt., 10 mi. E of Terrace, Ohlsson 2717 (MSC); VANCOUVER I.: locality unknown, 1858-59 Lyall (FH), 1901 Crosley (MICH), Sea's Farm, 25 Aug. 1908 Macoun (CAN), 17 June 1908 (FH), Carmannah, Macoun s.n. (CAN), Broughton Strait, Trelease 1276 (MSC), Sidney, Macoun 254 (CAN, FH), 281 (FH), Colquitz River, 10 June 1808 Macoun (CAN), Saltspring I., Baynes Peak, Brodo 13887 (CAN); NE of Healy Lake, 1950 Krajina, Spilsbury, & Szczawinski

(DUKE), Nanaimo, Macoun 413 (CAN), Nanaimo River Valley, July 1950 Szczawinski (DUKE), 8 Oct. 1950 Krajina, Spilsbury, & Szczawinski (DUKE); Wolf Mt., SE of Blackjack Mt., 27 July 1950 Krajina, Spilsbury, & Szczawinski (DUKE), Goldstream Prov. Park, N of Victoria, Ohlsson 1183, 1184 (MSC), Buttle Lake, Ohlsson 1649, 1691, 1694, 1689, 1677, 1681, 1671 (MSC); Mt. Becher, W of Courtenay. Ohlsson 1707A (MSC); Forbidden Plateau, W of Courtenay, Ohlsson 1798 (MSC); 8 mi. NW of Port Alberni, Sproat Lake, Ohlsson 1803 (MSC); Englishman Falls Campground, W of Parksville, Ohlsson 1804 (MSC); Departure Bay, 25 June 1908 Macoun (FH), Ucluelet, 5 May 1909 Macoun (FH, CAN), N of Kennedy Lake, 10 mi. NE of Ucluelet, Ohlsson 1118, 1123, 1124, 1131, 1138, 1145 (MSC), Chesterman Beach, S of Tofino, Ohlsson 1070, 1073A, 1084, 1091 (MSC), Mt. Cain, N of Schoen Lake, Ohlsson 1200, 1202 (MSC), Schoen Lake, Ohlsson 1276, 1276, 1287, 1293, 1307 (MSC), Halgren Park, Marble River, N of Port Alice, Ohlsson 1322, 1323, 1320, 1326, 1335, 1324 (MSC), Nimpkish River Campground, 5 mi. SE of Port McNeill, Ohlsson 1531, 1563, 1561, 1555, 1549 (MSC), Holberg, Ohlsson 1482, 1477, 1476, 1471, 1467, 1466, 1465, 1457 (MSC), 3 mi. NE of Coal Harbor, Ohlsson 1441, 1453, 1437, 1435, 1432, 1430, 1428, 1424, 1423, 1422, 1421 (MSC); Thurlow I.: 1885 Dawson (CAN); QUEEN CHARLOTTE IS. Lina I., Brodo 11297 (CAN); Moresby I.: Kwuna Point, E of Alliford Bay, Brodo 11208 (CAN), between Sandspit and Cooper Bay, Brodo 12875 (CAN), E end of Mike Inlet, Brodo 14162 (CAN), 1 mi. E of Laing Point, Brodo 10790 (CAN), Skidegate Lake, Brodo 11094 (CAN, MSC), Deena River, Brodo 10867 (DUKE, CAN), Murchison I., S of Lyall I., Brodo 11581B (CAN); Graham I.: 4 mi. N of Moulton

Lake, Brodo 9950 (CAN); Yakoun River, 5 mi. S of Yakoun Lake, Brodo 11664 (CAN), Tarundl Creek, Brodo 11629 (CAN), Jalun Lake, Brodo 12911B (CAN), 10.6 mi. N of Port Clements, Brodo 9820 (CAN), SE of Port Clements, Brodo 9811 (MSC), Skidegate Inlet, Legace I., Brodo 11400 (CAN), Long Inlet, Brodo 11439 (CAN), Skidegate, 1910 Spreadborough (FH). - WASHINGTON. locality unknown, Weir s.n. (MICH), Evans 49 (US), 1856 Newberry (FH-Tuck. 3742), Foster 337 (FH), Turtle Back Mt., Fink 461 (MICH), Lake Kachess, 1932 Svihla (MICH), Cascade Mts., 1925 Grant (MICH); CLALLAM CO.: Olympic Hot Springs, Smith 1996, 1965 (FH, MICH), 2003 (MICH), Cape Alava, Brown & Muenscher 127 (FH), Elwha River, Smith 2504 (FH), Elwha, trail to Olympic Hot Springs, 1922 Braun (DUKE), Elwha River Valley, Tucker 8228 (DUKE), Boulder Lake Trail, Smith 13816 (MICH, FH), Olympia, coll. unknown (FH), Cresent Lake, Weir 16680 (FH), Smith 2282, 1956 (MICH), 2263 (FH, MICH), SW of Port Angeles, 1952 Maslin (DUKE), Sequim, 1916 Grant (FH), 400 (FH); GRAYS HARBOR CO.: near Montesano, Heller 4299 (MSC); ISLAND CO.: Whidbey Is., Grant 3151 (FH), Langley, 1922 Grant (DUKE), 1923 Grant (US, DUKE); JEFFERSON CO.: Hoh River, Brodo 13219A (CAN), near Lake Leland, Schallert 11173 (MICH), Brown & Muenscher 128 (FH, MICH); KITTITAS CO.: Snoqualmie, Darrow 60 (MICH, FH); KLICKITAT CO.: White Salmon River, 1882 Faxon (MSC); PACIFIC CO.: 20 mi. S of South Bend, 1939 Herre (MICH, MSC); PIERCE CO.: Laughing Water Creek trail, Imshaug 332 (MICH), White River, Imshaug 450 (MICH), Ohanapecosh River, Imshaug 494, 737 (MICH), Nisqually River, Imshaug 1369, 1379 (MICH), Grassi 2 (CAN, MICH, FH, MSC), Longmire Springs, 1904 Frye (FH), Mt. Rainer, Foster 379 (FH), Tohoma Creek, 1954 Pechanec (CAN), Imshaug 1838 (MICH), Deer River Crossing, Ohlsson 1849 (MSC), Cowlitz Divide, Imshaug 161 (MICH), Cataract Falls, Imshaug 516 (MICH); SAN JUAN CO.: Mt. Constitution, Cowles 463 (MSC), Frye 7 (MICH), Fink 318 (MICH), Friday Harbor, Fink 203 (MICH); SKAGIT CO.: Marblemount, Mains 6156 (MICH), Mt. Erie, 8 mi. S of Anacortes, Brodo 13136 (CAN, MSC); WHATCOM CO.: locality unknown, 1858 Lyall (FH-Tuck. 3742), Mt. Baker Nat'l. Forest, above Mt. Baker Lodge, Brodo 13023 (TNS, CAN); WAHKIAKUM CO.: Cathlamet, Foster 508 (FH), 2 mi. above Cathlamet, Foster 490 (FH). - OREGON. locality unknown, coll. unknown (MSC, FH), Calkins [? collector] 79, 119 (FH), 1883 Brown (FH), 1871 Hall (FH-Tuck. 3743), Cala Valley, Barber 24 (FH), Palmer, 1932 Lawrence (US), coastal Mts., 1880 Summers (MICH), Cascade Mts., Pringle (FH-Tuck 3743); CLATSOP CO.: Seaside, 1911 Kerr (US), TILLAMOOK CO.: Neskowin, 1932 Lawrence (US), W of Nehalem, Shushan SL-2200 (MSC); WASHINGTON CO.: Forest Grove, Sweetser 1 (FH, MSC); YAMHILL CO.: McMinnville, 1878 Summers (FH), near Newberg, Tolstead s.n. (MICH); MULTNOMAH CO.: Larch Mt., Shushan SL-1893 (MSC), Gruber 603 (MICH), Miller 8539, 8500 pro parte (CAN); CLACKAMAS CO.: above Rhododendron, Christopher 14, 4 (MICH), Mt. Hood, 1880 Eckfeldt (CAN), 1922 Wehmeyer (MICH); HOOD RIVER CO.: NE of Mt. Hood, E fork of Hood River, 1938 Ownby (MSC); MARION CO.: Cascade Mts., coll. unknown (F); LINN CO.: NW of Sisters, Shushan SL-3915 (MSC); LANE CO.: Eugene, Sipe 735 (MICH), E of Blue River, Shushan SL-1887 (MSC); BENTON CO.: Corvalis, 1925 Sipe (MICH), Sipe 23 (US), NW of Philomath, near Marys River, Shushan SL-2100 (CAN): JEFFERSON CO.: coll. unknown (MICH). - CALIFORNIA. locality unknown, Calkins [? collector]

327 (F), coast, Edward 229 (FH), Santa Cruz Mts., 1885 Farlow (F), 17 Jan. 1903 Herre (F): DEL NORTE CO.: Patricks Creek Canyon, 25 mi. from Crescent City, Chase 6 (US), Smith River Trail, Cooke 26719 (DUKE, F); SISKIYOU CO.: Elk Creek Public Camp, coll. unknown 26833 (F); HUMBOLDT CO.: Kings Mt., Herre 177 (F), Kneeland, Parks 3696, 44 (F), Eureka, 1896 Howe (MSC), Carlotta, Wilder 6 (US); TRINITY CO.: E Fork Public Camp, 1939 Wing (F); MENDOCINO CO.: 1896 Howe (F), along Plantation road, Koch 997 (MSC); SONOMA CO.: near coast, Baker 82 (F), W of Larkspur, Brown 267 (F); MARIN CO.: locality unknown, 1903 Schneider (F), 14 mi. from Petaluma to Tomales, Koch 374 (MICH, FH, F); ALAMEDA CO.: Oakland, Bolander s.n. (MICH, F); SAN MATEO CO.: Pilarcitos Creek, Herre 211 (F, MSC, FH), Pilarcitos Creek Cañon, 22 May 1942 Herre (F), San Bruno Mts., 30 April 1942 Herre (MICH), 7 May 1942 Herre (F), point, San Pedro, 22 May 1942 Herre (F); SANTA CLARA CO.: Folger ranch, above Searsville, Herre 487 (F, FH, MSC, MICH), Searsville, Mann s.n. (FH), Bolander s.n. (F), Devils Cañon, 5 Feb. 1936 Herre (F), 16 Oct. 1903 Herre 279 (F), 28 July 1905 Herre 690 (MSC, MICH, FH, F), LaHonda, Herre 218 (F). -

FINLAND. Petsamo, 1931 Räsänen (MSC). - SWEDEN. locality unknown, 1842 Areschong (FH-Tuck. 3749), Erickson 293 (MSC); ÄLVSBORG: Toarp, Skår, 1910 Olsson (FH), Kallunga, 1880 Hulting (CAN), Alingsås, 1896 Stenholm (DUKE), Borås, Hultaberg, 1914 Vrang (FH); ÖSTERGÖTLAND: Risinge, Westerberg s.n. (DUKE); JÖNKÖPING. locality unknown, 1874 Zetterstedt (MSC); ÖSTERGÖTLAND. Ydre, Svinhult, 1871 Dusén (DUKE). - NORWAY. HORDALAND: Granvin, 1895 Havaas (DUKE), Bergen, coll. unknown (MICH); SÖR-TRÖNDELAG: locality unknown, 1932 Breien (MSC); AKERSHUS: Olso, Blyff [?] s.n. (MICH). - GERMANY. Notschrei, 1893 Lind [?] (FH); Black Forest, N part, 1909 Voigtländer-Tetzner (FH); Black Forest, 1927 Baacci (MSC); Baden, Black Forest, S part, 1926 Hillmann (FH); Schleswig-Holstein, Fleusburg s.n. (MSC), 1928 Fleusberg (DUKE). - BELGIUM. locality unknown, Gravet 1272 (FH), 1894 coll. unknown (MICH). - FRANCE. VOSAGES: locality unknown, 1884 Pierrat (FH); ILLE-ET-VILAINE: Vitré, coll. unknown (MSC); FINISTÈRE: Roc Trévezel, Culberson 10502 (DUKE); MORBIHAN: locality unknown, coll. unknown (FH); CANTAL: locality unknown, 1880 Arsène (FH). - MADEIRA IS. locality unknown, coll. unknown (BM). - ENGLAND. CORNWALL: Bodmin Moor, 1939 Lamb (CAN). - WALES. MERIONETHSHIRE: 4 mi. S of Trawsfynydd, Culberson 11942 (DUKE), Penmaenpool, Culberson 11549, 14023, 11558 (DUKE), 14021 (DUKE, TNS), Cader Idris, Brodo 4984 (MSC, CAN), 4930 (CAN), 1883 Bower (MICH); ANGLESEY: Holy I., Holyhead, S stack, Culberson 12025 (DUKE). - SCOTLAND. ARGYLL: W of Salem, Culberson 11554, 11747 (DUKE), 14101 (MSC); PERTH: Ben Lawers, 1905 Wheldon (FH). - IRELAND. locality unknown, 1841 Drummond (FH-Tuck. 3749). - ICELAND. Hestfjall, 24 July 1937 Lynge (CAN). - GREENLAND. locality unknown, 1889 Hartz (FH). -

CHILE. PROV. MAGALLANES: Tierra del Fuego, coll. unknown (PC, FH-Tuck. 3750), I. Horn, Hariot 27 (PC), Hermite I., 1842 Hooker 63 (BM, FH-Tayl. 149), Port Famine [Puerto del Hambre], Jacquinot 12 (PC), Bahia Orange [I. Hoste], 1883 Hariot (PC-Hue). - ARGENTINA. I. Grande, Paso Garibaldi, Imshaug 54887 (MSC), Roivainen

881 (MSC), 1 km S of Paso Garibaldi, Imshaug 55387 (MSC), W side of Bahia Lapataia, Imshaug 55056, 55051 (MSC), B. Buen Suceso, Imshaug 50047, 50043, 50025, 49979, 49962 (MSC), B. Valentin, Imshaug 50372, 50358, 50332, 50312, 50279 (MSC); I. Estados: P. Cellular, Imshaug 52540, 52472 (MSC), P. Alexander, Imshaug 52745 (MSC); P. Basil Hall, Imshaug 51328 (MSC): B. Capitan Canepa, Imshaug 52919, 52898, 53008, 53142 (MSC); B. Crossley, Imshaug 50544A, 50536B (MSC); P. Hoppner, Imshaug 53700, 53749, 53829 (MSC); P. Parry, Imshaug 53857, 54014 (MSC); B. Primera, Imshaug 52299 (MSC); P. Cook-Vancouver, Imshaug 52180 (MSC); P. Cook, Imshaug 52149, 51712, 51594, 51563 (MSC); P. Vancouver, Imshaug 52202, 52194, 52075, 52059, 52072 (MSC); P. San Juan, Imshaug 51758 (MSC); P. Roca, Imshaug 51170 (MSC); B. Crossley, Imshaug 50525 (MSC); B. Flinders, Imshaug 53467, 53405, 53362, 53355, 53268 (MSC); C. San Bartolome, Imshaug 53171, 53197, 53219, 53229, 53233 (MSC); I. Observatorio, Imshaug 50981 (MSC). - FALKLAND IS. locality unknown, coll. unknown (H-Nyl. 40386), Hooker s.n. (BM), Hooker 19 (BM, FH), Black s.n. (BM), 1927 Schmitt (US), Robinson s.n. (BM), Edmunistum s.n. (BM), Gaudechaud 127 (PC). W. FALKLANDS. Fox Bay, Imshaug 42390, 42291, 42297, 42330, 42241, 42178A, 42186C, 42189, 42096, 42108 (MSC); Weddell I., Mt. Weddell, Imshaug 41941 (MSC), Circum Peak, Imshaug 41995 (MSC), Waterfall Valley, Imshaug 41869, 41912 (MSC); New I., Imshaug 41785, 41820, 41750 (MSC); Port Howard, Freezer Rocks, Imshaug 41353 (MSC), Mt. Maria, Imshaug 41385 (MSC); Hill Cove, Imshaug 41216, 41212, 41225, 41248, 41198, 40957, 40975, 40998B, 41011 (MSC); Mt. Adam, Imshaug 41063, 41065, 41136 (MSC); Westpoint I., Imshaug 40817, 40861 (MSC);

E. FALKLANDS. Port William Stanley, Lechler 72 (BM, PC-Hue, PC); Port William, Mt. Low, Imshaug 41581 (MSC), N of Hell's Kitchen, Imshaug 41617, 41611 (MSC), Engineer Point headland, Imshaug 40624, 40610 (MSC), Pembroke peninsula, Imshaug 39086, Darwin Settlement, Imshaug 40297 (MSC); Mt. Usborne, Imshaug 40151, 40132, 40078, 40025, 39956, 39916, 39899, 39871 (MSC); Port Stanley, March 1906 Sargent (FH), 26 Oct. 1905 Thaxter (FH); Stanley, Mullet Creek, Imshaug 41458 (MSC), Mt. Harriet, Imshaug 41565 (MSC), Mt. Kent, Imshaug 40427, 40484 (MSC), Two Sisters, Imshaug 40401, 40357 (MSC), Sapper Hill, Imshaug 39730, 39717, 39789 (MSC), Tumbledown Mt., Imshaug 39688, 39683 (MSC).

Chemotype III (Sphaerophorin and squamatic acid)

Exsiccati seen.--Arn. 1146C (MICH); Cum. II. 257 (MSC); Harm Loth. 148, 149 (MSC); Hepp Flech. Europ. 217, 422 (FH); Malbr. 105 (MSC); Merr. 56 (MSC); Mig. 19 (MSC, MICH): Moug. 262 (FH-Tuck. 3748, FH-Tayl. 148 & 149); Norrl. 53 (MSC, FH-Tuck. 3748); Räs Hel. 328 (MSC); Rel. Suza. 14 (MSC); Sampaio 33 (MSC); Schaer, 453 (FH-Tuck. 3749); Stenh. 58 (FH-Tuck. 3750, MICH); Thoms. 4 (MICH).

Specimens seen.--MAINE. locality unknown, 1844 Russell (FH-Tuck. 3741). - NEW BRUNSWICK. locality unknown, coll. unknown (MICH). - NOVA SCOTIA. VICTORIA CO.: 8 mi. up Clyburn Valley from Ingonish, Lamb 7003 (MICH). - NEWFOUNDLAND. locality unknown, 1902 Sornborger (FH); Salvage, Taylor 1971 (MSC); Notre Dame Bay, Pyke I., Riewe P49 (CAN). - NORTHWEST TERRITORIES. locality unknown, Steere 12868 (MICH); KEEWATIN DIST.: Iguliguar [?], Dutilly

9048b (MICH); FRANKLIN DIST.: Baffin I.: Pangnirtung, Polunin 2611a-26 (FH), Annanactook Harbour, 1877-78 Howgate Exped. (FH-Tuck. 3740). - YUKON. MeQuesten Area, S Klondike Body, Campbell 657 (CAN). - ALASKA. Wrangel, Coville & Kearney 405 (MSC); Baranoff I., Sitka, Trelease 1278 (MSC); Montana Creek Road, Juneau, Imshaug 28659 (MSC); Juneau, Saunders 1273 (MSC); Skagway, 1902 Macoun (FH), Cowles 1026 (F); Point Gustavus, Coville & Kearney 781 (DUKE); Yakutat Bay, Trelease 1289 (MSC); Orca, Setchell 1217 (MSC), Trelease 1271 (MSC); Orca, Hinchinbrook I., Norberg 207, 213 (MSC), 4 Aug. 1937 Norberg (MICH); Knight I., Thum Bay, Prince William Sound, Eyerdam 281a (FH); Kodiak I., Eyerdam s.n. (MICH); Mt. Eielson, Mt. McKinley Nat'l. Park, Weber & Viereck S7086 (CAN): Port Clarence, 1899 Trelease (MSC); E of Okpilak Lake, Cantlon & Malcolm 58-619 (MSC); Jago River, S of Jago Lake, Cantlon & Gillis 57-1497 (MSC); W side of Jago River, Cantlon 57-661 (MSC); St. Lawrence I., Trelease 1275 (MSC); Diomede I., 1924 Palmer (FH); St. George I., J. M. Macoun 57 (CAN); Kinkaid 28 (MICH); St. Paul I., J. M. Macoun 183 (CAN); St. Matthew I., 15 July 1899 Trelease (MSC); Hall I., Coville & Kearney 781, 2062 (MSC), 1899 Trelease 1282 (MSC); Nunivak I., Palmer 340P (FH); Aleutian Is., 1945 Van Schaack (MSC), Bank R-36C (MICH); Unalaska, 13 May 1932 Eyerdam (MICH, CAN, MSC), Miller 895 (MICH); Amlia I., 10 July 1932 Eyerdam (MICH); Atka I., 1931 Kobayashi (TNS), Bank 937 (MICH), 1 July 1932 Eyerdam (MSC); Tanaga I., Miller 1103 (MICH); Amchitaka I., Reich & McCann 76, 246 (CAN); Attu I., Howard 1 (US), 1931 Kobayashi (TNS). - BRITISH COLUMBIA. locality unknown, Macoun 37 (FH), 26 Feb. 1914 Macoun

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(CAN), Lowe Inlet, Trelease 1277 (MSC), New Westminster, Hill 1577 (MSC), Manning Prov. Park, Brodo 7847 (CAN), near Revelstoke Jordan Creek, Cleland 22 (US), 5513 (MICH), near Alice Lake Prov. Campground, N of Squamish, Ohlsson 449, 453 (MSC); N of Cheekye, Ohlsson 494 (MSC), Black Tusk Area, Garibaldi Prov. Park, Ohlsson 563, 548, 611, 622, 627 (MSC); N of Alta Lake, Garibaldi Prov. Park. Ohlsson 636 (MSC), SW of Port Mellon, Ohlsson 890 (MSC), mountain, 15 mi. NE of Stillwater, Ohlsson 927, 935, 943, 973, 980, 993 (MSC), 5 mi. W of Bella Coola, Clayton Falls Creek, Ohlsson 2129 (MSC), 10 mi. S of Furlong Bay Prov. Campground, Ohlsson 2705 (MSC), Lakelse, Ohlsson 2602 (MSC); VANCOUVER I.: Sidney, 24 Nov. 1913 Macoun (FH), Wolf Mt., SE of Blackjack Mt., 27 July 1950 Krajina, Spilsbury, & Szczawinski (DUKE), Goldstream Prov. Park, N of Victoria, Ohlsson 1187 (MSC), Buttle Lake, Ohlsson 1645 (MSC), Mt. Becher, W of Courtenay, Ohlsson 1707A (MSC), Forbidden Plateau, W of Courtenay, Ohlsson 1796 (MSC), Mt. Cain, N of Schoen Lake, Ohlsson 1212, 1211, 1260 (MSC), Schoen Lake, Ohlsson 1287, 1307 (MSC), Halgren Park, Marble River, N of Port Alice, Ohlsson 1320 (MSC), 3 mi. NE of Coal Harbor, Ohlsson 1438, 1432, 1424 (MSC); Thurlow I., 1885 Dawson (CAN); QUEEN CHARLOTTE IS. Moresby I.: Van Inlet, Brodo 10215 (CAN); Graham I.: Jalun Lake, Brodo 12911A (CAN), Langara I., Brodo 10643 (CAN). - WASHINGTON. Mt. Pilchuck, Eyerdam 1013 (DUKE), Cascade Mts., Brandages s.n. (FH); CLALLAM CO.: Olympic Hot Springs, Smith 1996, 2121 (MICH), 1965 (FH), cape Alava, Brown & Muenscher 127 (MICH), Elwha River valley, 8 mi. above Humes, Frye 8 (MICH, FH), Cresent Lake, Smith 1833 (MICH); KITSAP CO.: mountainers cabin, 1940 Eyerdam (MICH); PIERCE CO.: Laughing Water Creek trail, Imshaug 332 (MICH), Kotsuck Creek, Imshaug 132 (FH, MSC, MICH); SNOHOMISH CO.: near Silverton, Perry Creek trail, Culberson 14399 (DUKE). - OREGON. Cascade Mts., Sargent s.n. (FH-Sprague), 1880 Sargent (FH), Pringle 21 (FH), 1881 Pringle (FH); WASHINGTON CO.: Forest Grove, Sweetser 1 (FH); LANE CO.: Eugene, Sipe 735 (MICH). - CALIFORNIA. Santa Cruz Mts., coll. unknown (FH), 1885 Farlow (FH, MICH); ALAMEDA CO.: Oakland, Bolander s.n. (FH). - MEXICO. Guadelupe I., coll. unknown (FH); 1875 Palmer (US, FH, MSC); Howell 34 (FH). -

JAPAN. HOKKAIDO.: Mt. Furano, Kurokawa 65405 (TNS); Mt. Daisetsu, 14 July 1936 Sato (MSC, FH), 25 July 1937 Asahina (TNS); Mt. Tomurausi, 31 Aug. 1935 Kujikawa (TNS). HONSHU. Yamanashi Pref.: Yatsugadake, 1926 Asahina (TNS). - U.S.S.R. Prov. Archangel, 1904 Pohle (MICH). -

FINLAND. Kyrkslätt, 1908 coll. unknown (FH). - SWEDEN. GÖTEBORGS OCH BOHUS: Marstrand 1892 Stenholm (FH); VASTMANLAND: Arboga, 1949 Kjellmert (CAN); STOCKHOLM: Nothamn, 1960 Nordin (DUKE); SODERMANLAND: Nikolai, 1916 Asplund (FH); ÖREBRO: Svennevad, 1947 Kjellmert (MSC); JÖNKÖPING: locality unknown, 1917 Henriksson (FH), Malmbäck, 1927 Haglund (MSC). - NORWAY. FINMARK: Gjaesvaer, 1906 Havaas (DUKE); HORDALAND: locality unknown, Lillefosse 500 (FH), Granvin, 1895 Havaas (DUKE), Sandnes, 1901 Havaas (TNS, MSC); OPLAND: Dovre, 1870 Zetterstedt (MSC); AUST-AGDER: Lyngor, 1905 Lynge (FH); VESTFOLD: Fredriksvern, coll. unknown (MSC). - GERMANY. Baden, coll. unknown (MICH). - FRANCE. Savoy, Mt.

Brezon, coll. unknown (FH-Tuck. 3749), Montagnes du Fores, 1887 Parrique (FH); MEURTHE ET MOSELLE: source of the Merthe, 1958 Werner (MSC); VOSAGES: locality unknown, coll. unknown (FH, MSC), 1884 Pierrat (MICH), Forêt Saint-Jacques, 1959 Werner (MSC), Mt. Hohneck, 1959 Werner (MSC); ILLE ET VILAINE: Forêt de Fougeres, coll. unknown (MSC); CANTAL. locality unknown, 1880 Arsène (FH); AVEYRON ET GARD: Mt. St. Guiral, 1900 Mare (MSC); HÉRAULT: Massif du Caroux, 1908 Crozals (MSC); HAUTE-GARONNE: Malhdera Pica, 1948 Séguy (DUKE); HAUTES-PYRENEES: locality unknown, coll. unknown (FH), Forêt de Gabas, 1909 Crozals (MSC). - SWITZERLAND. locality unknown, Schleicher 345, 347 (MSC). - CANARY IS. TENERIFE.: Mt. de Gala, Imshaug 36155 (MSC). - MADEIRA IS. locality unknown, 1865 Mandon [?] (H-Nyl. 40379). Pico do Arieiro, Alanko 130, 197, 201 (H). - ENGLAND. CORNWALL: Bodmin Moor, Rough Tar, Lamb 846 (MSC); DEVONSHIRE: Lustleigh Clue, Dartmoor, coll. unknown (DUKE), Dartmoor Forest, 4 mi. W of Mortonhamstead, Culberson 14089 (DUKE), Berry Down, 1938 Stephenson (FH). - WALES. MERIONETHSHIRE: 4 mi. S of Trawsfynydd, Culberson 11939 (MSC). - SCOTLAND. locality unknown, coll. unknown (FH-Tuck. 3749, FH-Tayl. 151), ARGYLL: Near N Port Sonochan, Lamb 975 (CAN); SUTHERLAND: locality unknown, 1910 coll. unknown (FH). - FAROES. Insula Osterö, 19 Aug. 1897 Hartz & Ostenfeld (CAN); Insula Sudero, 16 July 1897 Hartz & Ostenfeld (FH); Thorsharn I., Simmons 643 (MSC); Dist. Suduroy, Hansen 231 (TNS); Dist. Streymoy, Langafjall, Hansen 227 (MICH).

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Chemotype IV (Sphaerophorin and hypothamnolic acid)

Specimens seen.--ALASKA. Cordova Sheridan Glacier, Anloit 1519 (DUKE); Knight I., Thum Bay, Prince William Sound, Eyerdam 293 (MICH); Bering Straits, Wright s.n. (FH-Tuck. 3742). - BRITISH COLUMBIA. mountain, 15 mi. NE of Stillwater, Ohlsson 943 (MSC); Hartley Inlet, W end of Douglas Channel, Ohlsson 2442 (MSC); trail to Robinson Lake, E of Kitimat, Ohlsson 2438 (MSC); Lakelse, Ohlsson 2602 (MSC); 21 mi. E of Terrace, Highway 16, Ohlsson 2833 (MSC); QUEEN CHARLOTTE IS. Skidegate Inlet, Balch I., Brodo 11582 (CAN); Moresby I.: Kwuna Point, E of Alliford Bay, Brodo 11208 (CAN), Yakulana Bay, Brodo 12225 (CAN), Copper Creek, E of Skidegate Lake, Brodo 11118 (CAN), Jedway, Brodo 12565 (CAN), Murchison I., S of Lyall I., Brodo 11581B (CAN); Graham I.: Port Lewis, Brodo 10484 (CAN), Hippa I., Brodo 10359 (CAN). - CALIFORNIA. Santa Cruz Mts., 1885 Farlow (BM). -

NORWAY. HORDALAND: Sandnes, 1901 Havaas (TNS). - GERMANY. Black Forest, 1927 Baacci (MSC). - CZECHOSLOVAKIA. Tatra Mts., coll. unknown (MSC). - SCOTLAND. RENFREW: Johnstone, coll. unknown (FH-Tayl. 149).

Chemotype V (Sphaerophorin, squamatic acid, and hypothamnolic acid)

Exsiccati seen.-- Leight. 316 (FH).

Specimens seen.--NOVA SCOTIA. GUYS CO.; Hartleys Falls near Port Mulgrove, Prince 6484 (FH). - NEWFOUNDLAND. Fort

McAndrew, Placentia Bay Region, 1943 Heinze (MSC). QUEBEC. Hudson Strait, Wolstenholm, Polunin 2252a-16 (FH): - ALASKA. Orca, 6 June 1937 Norberg (MICH); Orca, Hinchinbrook I., 4 Aug. 1937 Norberg (CAN). - BRITISH COLUMBIA. Brackendale, 1916 Macoun (FH); SW of Kishkosh Inlet, Douglas channel, Ohlsson 2476 (MSC); VANCOUVER I.: Victoria, Burnside Road, 6 May 1893 Macoun (CAN), Nanaimo, Macoun 413 (CAN); QUEEN CHARLOTTE IS. Moresby I.: E end of Mike Inlet, Brodo 14162 (CAN), head of Newcombe Inlet, Brodo 14335 (CAN(, between De la Beche and Haswell Bays, Brodo 11973 (CAN), Jedway, Brodo 12470, 12493 (CAN); Graham I.: Skidegate Inlet, Brodo 11500 (CAN), Tow Hill, Brodo 9911 (CAN), Carew Bay Mt., Brodo 10258 (CAN), Port Lewis, Brodo 10484 (CAN), Langara I., Brodo 10666 (CAN). - WASHINGTON. KING-KITTITAS CO.: Snoqualmie Pass, Howard 812 (FH); PIERCE CO.; White River, Imshaug 400 (MICH). - OREGON. BENTON CO.: NW of Philomath, near Marys River, Shushan SL-2100 (CAN). - CALIFORNIA. locality unknown, Bolander 27 (FH-Tuck. 3742); HUMBOLDT CO.: Eureka, 1896 Howe (F); SANTA CLARA CO.: near Saratoga, 1957 Cain (DUKE). - U.S.S.R. Arakamchechen I., Bering Straits, Wright s.n. (FH). -

SWEDEN. ÄLVSBORG: Langared, 1944 Hasselrot (CAN); GÖTEBORGS OCH BOHUS: Vrango, 1960 Nordin (TNS); VÄSTMANLAND: Arboga, 1946 Kjellmert (MSC); VÄRMLAND. Olme, 1872 Falk (DUKE); JÖNKÖPING: Ryclaholm, 1926 Haglund (MICH). - NORWAY. Skrambygden på Vagsä, 1903 Havaas (DUKE); HORDLAND: locality unknown, Lillefosse 504 (FH), Sandnes, 1901 Havaas (DUKE); VESTAGDER: Egersund, 1901 Havaas (DUKE); OPLAND: Dovre, 1916 Lynge (CAN). - BELGIUM.

locality unknown, Maas 3876 (DUKE). - FRANCE. FINISTERE: Pointe de Pen-Hir, Culberson 10508 (DUKE). - PORTUGAL. Serra do Gerez-Leonte, Tavares 2106 (CAN). - ENGLAND. Cronkley Fell, West 65 (FH); LANCASHIRE: Salter Fell, 1904 Wilson & Wheldon (FH); CORNWALL: Bodmin Moor, Rough Tar, Lamb 846 (MICH, DUKE, FH), Bodmin Moor, Lamb 550 (CAN), Lands End, Culberson 11550 (DUKE); DEVONSHIRE: Berry Down, 1938 Stephenson (FH). - WALES. MERIONETHSHIRE: S of Trawsfynydd, Culberson 11939 (DUKE); ANGLESEY: Holy I., Brodo 5144 (CAN); CAERNARVONSHIRE: Cors-y-celyn, Llyn Gwyant, Brodo 5069 (CAN). - SCOTLAND. ARGYLL: Ben Arthur, 1938 Hunter (FH). - IRELAND. locality unknown, coll. unknown (FH), shores of Lough Bray, 1909 Adams (US). - FAROES. locality unknown, 1896 coll. unknown (DUKE), 7 Aug. 1897 Hartz & Ostenfeld (CAN).

Chemotype VI (Sphaerophorin, squamatic acid, and thamnolic acid)

Exsiccati seen.--Räs Hel. 328 (MICH); Vezda Bohen. 31 (DUKE, MSC).

Specimens seen.--ALASKA. Knight I., Thum Bay, Prince William Sound, Everdam 230 (FH). - BRITISH COLUMBIA. VANCOUVER I.: locality unknown, 1858-59 Lyall (FH-Tuck. 3743); QUEEN CHARLOTTE IS.: Graham I., 8 mi. S of Juskatla, Brodo 11678 (CAN). - CALIFORNIA. SANTA CLARA CO.: Devils Cañon, 16 Oct. 1903 Herre 279 (FH). - SWEDEN. Vastergotland, 1919 Stenholm (MICH). - NORWAY. MÖRE OG ROMSDAL: locality unknown, 1957 Klement (DUKE). - GERMANY. Black Forest, Notschrei, Voigtländer-Telzner s.n. (DUKE). - FRANCE.

HAUTES-PYRENEES: locality unknown, 1920 coll. unknown (DUKE). - ITALY. locality unknown, Anzi s.n. (DUKE). ENGLAND. Cronkley Fell, West 65 (US); BERKSHIRE: near Bray, Templeton s.n. (FH-Tayl. 156). - SCOTLAND. ARGYLL: Salen-Ardnamurchan Peninsula, Culberson 13978 (DUKE), Ardnamurchan Peninsula, near Archdale, Culberson 13969 (MICH, DUKE); INVERNESS: Moidart Peninsula, near Kinlochmoidart, Culberson 13989 (DUKE).

4. Sphaerophorus meiophorus (Nyl.) Vain.

Bot. Mag. (Tokyo) 35: 74. 1921. Sphaerophoron coralloides*[subsp.] meiophorum Nyl. Lich. Japan 16. 1890. Sphaerophorus coralloides var. meiophorus (Nyl.) Hue, Nouv. Arch. Mus. Hist. Nat. ser. 3. 10: 233. 1898. Sphaerophorus globosus f. meiophorus (Nyl.) Zahlbr. Cat. Lich. Univ. 1: 692, 1922. Type: Japan, Itchigome, Umagayeshi, 1879 E. Almquist (H-Nyl. 40369, holotype).

Sphaerophorus compressus f. congerens Hue, Nouv. Arch. Mus. Hist. Nat. ser. 3. 10: 235. 1898. Sphaerophorus melanocarpus f. congerens (Hue) Zahlbr. Cat. Lich. Univ. 1: 695. 1922. Type: Japan, I. Nippon, summit Mt. Gansu, R. P. Faurie 741 (FH, isotype).

Nomenclatural Remarks

Hue (1898) described S. compressus f. congerens from Japan and in the same paper discussed separately S. coralloides var. meiophorus, believing the two to be sufficiently distinct to place in two species. Material at the Farlow Herbarium collected by

Faurie and identified by Hue has been selected as isotype material of this species, with the holotype assumed to be in the Hue herbarium.

Description

Thallus corticolous, caespitose, well developed, producing numerous crowded upright to decumbent branches interlacing with each other. Primary branches subterete to more commonly terete, 2-4 (6) cm in length, 0.5-1.2 mm in width, with occasional short corolloid branchlets; secondary branches irregular to anisotomic dichotomous, similar in size to the primary branches. Surface smooth, dullish, grayish green to grayish brown. Cortex 70-100 μ thick, composed of thick-walled gelatinized, fused, hyphae, intricated in various directions and covered by a thin (1-3 μ) colorless epicortex. Algal-medullary layer 15-30 μ thick, encircling the medulla; algae, protococcoid, spherical, 8-12 μ in diameter. Central medulla very dense, composed of thick-walled, longitudinally arranged, hyaline to organgish hyphae, 5-7 μ in diameter, generally fused to form a core-like central strand. Apothecia common, terminal, 1.0-1.8 mm across. Mazaedium oriented apically, exposed at an early stage of development by the apical rupture of the enclosing receptacle; when mature globose, black, partially surrounded by the receptacle. Asci cylindric, near maturity, 40-65 X 5-8 μ, containing 8 spores arranged in a row. Spores spherical to braodly ellipsoid, greenish becoming blue when mature, 8-10 μ in diameter, commonly surrounded by a dark carbonaceous material. Pycnidia occasional in the apical areas; microconida, rod-shaped, 3-5 X 1 μ.

Medullary reactions.--PD -, KOH -, KC -, C -, I -.

Constituents.--Sphaerophorin and squamatic acid, found in all 60 specimens.

Discussion

Sphaerophorus meiophorus is a Japanese species occurring at high elevations from Hokkaido to Kyushu. It is closely related morphologically to *S. fragilis* with similar apothecial development and spore characters. Chemically they are also similar, both species producing squamatic acid in addition to sphaerophorin. *Sphaerophorus meiophorus* differs by having a much better developed and branched thallus and producing a very dense, almost core-like central medulla. They also differ in substrate, with *S. meiophorus* occurring only on wood and *S. fragilis* restricted to rock or rock crevices and barren soil.

Material Examined

Specimens seen.--JAPAN. Fizogataki, Faurie 5498 (FH), Itchigome, 1879 Almquist (H-Nyl. 40369), Gansu, Faurie 741 (FH); SHIKOKU. locality unknown, Faurie 2658 (FH). KYUSHU. Oita Pref.: Mt. Ontake, Kurokawa 64161, 64173 (TNS). HONSHU. Shizuoka Pref.: Fuji-san, Culberson 10768, 11105, 10772, 11106, 11097 (DUKE), Mt. Fuji, 1925 Asahina (TNS), 1925 Numajiri (TNS); Nagano Pref.: Yumatazawa, Kurokawa 51624 (TNS), Mt. Eboshi, Kurokawa 520251 (TNS), Komagatake, Asahina s.n. (TNS), Mt. Ainotake, Koidzumi 71551, 71538 (TNS), Azusayama, Kurokawa 520741 (TNS), Mt. Azumaya, Kurokawa 50225

(TNS),

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(TNS), Sensui Pass, Koidzumi 71487 (TNS), Mt. Tadeshina, Kurokawa 51771, 510011 (TNS), Mt. Kimpu, Kurokawa 65153, 520205, 65232, 65154, 65152 (TNS), trail from Jumonji Pass to Mt. Kobushi, Kurokawa 520904 (TNS), trail from Mt. Kokushi to Mt. Kobushi, Kurokawa 540265 (TNS), Mt. Kokushi, Kurokawa 520105 (TNS), Yatsugatake Mts., Kurokawa 58192 (TNS), Mt. Akadake, Kurokawa 51135 (TNS), Mt. Tengu-dake, Kurokawa 58214 (TNS), Mt. Takamiishi, Kurokawa 58285 (TNS, US); Chiba Pref.: Mt. Tateyama, 1937 Nishijima (TNS), Magawa, 1936 Asahina (TNS), Mt. Kenzan, 1934 Fujikawa (TNS); Yamanashi Pref.: Mt. Hitimen, 1922 Asahina (TNS), Mt. Mizugaki, Kurokawa 521106 (TNS), Mt. Kimpu, Kurokawa 521162 (TNS); Saitama Pref.: Mt. Ryogami, Chichibu, Kurokawa 550603, 550602 (TNS); Chichibu, 1933 Asahina (TNS), Mt. Shiroiwa, Chichibu, Kurokawa 50372 (TNS), Mt. Kumotori, 7 July 1932, 6 July 1932 Kusaka (TNS), Kurokawa 510304 (TNS), Kobushidake-Chichibu Mt. region, Omura 409 (US); Tochigi Pref.: Karikomi-ko, near Nikko, Culberson 11060 (DUKE), Sanno Pass, Nikko, Kurokawa 64042 (TNS), Yumoto, Nikko, 1923 Asahina (TNS), Karikomi, Nikko, 1930 Hashimoto (TNS), Karikomi, Nikko, 1931 Asahina (TNS). HOKKAIDO. Mt. Daisetu, 1936 Sato (TNS), 1932 Fujikawa (TNS), 25 July 1937, 27 July 1937 Asahina (TNS).

5. *Sphaerophorus stereocauloides* Nyl.

Flora 52: 69. 1869. *Thysanophoron stereocauloides* (Nyl.) Sato, Misc. Bryol. Lichenol. 4(3): 48. 1966. Type: New Zealand, 1867 Knight (H-Nyl. 40395, holotype; BM, isotype).

Thysanophoron pinkertoni Stirt. Trans. & Proc. Bot. Soc. Edinburgh 14: 359. 1883. Type: New Zealand, North Island, Wellington ?, R. Pinkerton (BM, lectotype).

Sphaerophorus nobilis Zahlbr. Denkschr. Akad. Wiss. Wien, Math.-Naturwiss. Kl. Denkschr. 104: 258. 1941. Type: New Zealand, Shkeart Mt. [?], South Island, Fiord District, W. A. Thomson Z. A. 424 (not seen).

Nomenclatural Remarks

Although Stirton was aware of the occurrence of cephalodia in the genus Sphaerophorus, he believed their presence was unique enough to describe a new genus, Thysanophoron. As other major characteristics are in keeping with the genus concept and as other genera, such as Peltigera and Lecidea, include some cephalodiate species, it is my opinion this species should be classified within Sphaerophorus. A photograph of the holotype is included in Figure 20.

Sphaerophorus nobilis is placed in synonomy with S. stereocauloides on the basis of the description in Zahlbruckner. Although the type material was not studied, the description of the coralloid branchlets, IKI + blue medullary reaction, and spore characters point clearly to this species.

Description

Thallus corticolous, usually producing one sparingly branched, well developed, primary branch. Primary branches usually fertile, erect, terete, up to 14 cm in length, 2-6 mm in width at

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the base, with terminal branchlets 1.0-1.5 mm in diameter. Branching irregular or anisotomic dichotomous, with numerous, short, coralloid or phyllocladial ramuli occurring in fasciculate groups. Cephalodia occurring with the phyllocladial ramuli, forming small cylindrical isidiod-like structures, up to 5 mm in length by 1.5-4.0 mm in width; varying in abundance from frequent to rare; containing the blue-green alga, Scytonema. Surface of the branches smooth, dull brown, transversely annulate-cracked. Cortex of the branches and cephalodia similar, 60-200 μ thick, composed of thick-walled gelatinized, fused hyphae intricated in various directions and covered by a thin (2-3 μ) colorless epicortex. Algal-medullary layer 40-60 μ thick, usually completely surrounding the medullary layer, but in larger branches may be absent on the lower side; algae protococcoid, spherical, 10-12 μ in diameter. Apothecia terminal, subglobose to globose, common, 1.5-4.0 mm in diameter. Mazaedium oriented apically, becoming exposed at an early stage of development by the apical rupturing of the enclosing receptacle; when mature globose, black, partially surrounded by the receptacle. Asci cylindric, near maturity 40-65 X 5-8 μ, containing 8 spores arranged in a row. Spores spherical to broadly ellipsoid, dark blue, 8-12 μ in diameter. Pycnidia common in apical areas.

Medullary reactions.--PD -, KOH -, KC -, C -, I +.

Constituents.--All 37 specimens examined contained only sphaerophorin.

Discussion

Morphologically S. stereocauloides is an isolated species probably being most closely related to S. globosus, having similar apothecial development, IKI medullary reaction, and spore characters in common. Characteristics found in S. stereocauloides which are not found in other species of Sphaerophorus are the production of the single large primary branches and the presence of cephalodia.

This species, endemic to New Zealand, is typically corticolous but several specimens have been found on the soil. It may be that the specimens found on soil have fallen from nearby trees. This species seems to occur commonly at high elevations in both North and South Islands of New Zealand.

Material Examined

Specimens seen.--NEW ZEALAND. locality unknown, coll. unknown (BM), Knight 104 (H-Nyl. 40395), Knight s.n. (BM), 1860 Sinclair (BM); NORTH I. locality unknown, Colenso s.n. (BM), 4571 (BM), Colenso & Bidwell s.n. (BM); near Wellington ?, Pinkerton s.n. (BM); Ruahine Range, Colenso 2202 (WELT); Mt. Tararua, 1882 Buchanan (BM). SOUTH I. Nelson: locality unknown, coll. unknown (BM). 0.4 mi. W of Rahu Saddle, Imshaug 55868 (MSC), Cobb River Dam, Mason 602 (OTA); Westland: Arthur's Pass, Murray 6880 (BM, OTA). Malvern: Bealey Track, Arthur's Pass, 1959 Cunningham (OTA), Bealey Glacier Vista, Imshaug 48173 (MSC), Harris 6400 (MSC), Avalanche Peak Track, Harris 6478 (MSC), Punchbowl Creek Track, Arthur'

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Arthur's Pass, _Imshaug 48186_ (MSC); Canterbury: Andrew River, _Scott 47, 51_ (OTA); Otago: locality unknown, coll. unknown (BM), _Hector_ (BM); Mr. Brewster, 1968 _Galloway_ (MSC); Southland: locality unknown, coll. unknown (BM), Doubtful Sound, _Wylie 1728/6_ (BM), Howden, _Murray 0800, 0841_ (OTA), Monowai, 1953 _Hamilton_ (OTA).

Subgenus BUNODOPHORUS (Mass.) Ohlsson, subg. comb. nov.

Thallus branches with an upper and lower surface; apothecia subterminal; spores grayish, globose, 5-10 μ in diam.

Type species: _Bunodophorus australe_ (Laur.) Mass. (=_Sphaerophoron australe_ Laur. (=_Sphaerophorus melanocarpus_ (Sw.) DC.)).

This subgenus, consisting of nine species, is a diverse group of related taxa. _Sphaerophorus madagascareus_ and _S. diplotypus_ have a medullary cavity and are the only two species in the genus with this feature. Most members produce stictic and constictic acids in addition to sphaerophorin, but _S. microsporus_ produces protocetraric acid. _Sphaerophorus ramulifer_ is the only species in the genus to produce isousnic acid and _S. dodgei_ contains sphaerophorin along with an unknown substance. This subgenus seems to have a generally tropical to subtropical distribution, although _S. melanocarpus_ is widespread in both the southern and northern hemispheres and _S. ramulifer_ is restricted to the cool temperate southern hemisphere (see Figure 39).

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6. Sphaerophorus diplotypus Vain.

Hedwigia 37: 36. 1898. Type: Madagascar, "Ad ramos motuos arborum in silva Ivohimanitra," Forsyth-Major 97 (BM, holotype).

Nomenclatural Remarks

Vainio separated S. diplotypus from S. madagascareus by the terminal apothecia in S. diplotypus and by the location of the KOH reaction in the medulla. He reported that S. madagascareus reacted KOH + on the inner parts of the medulla, whereas S. diplotypus reacted KOH + only on the outer part of the medulla. In this study both species are found to contain stictic and constictic acids as medullary products. A photograph of the holotype specimen is shown in Figure 1.

Description

Thallus corticolous, caespitose, short to elongated, with several erect or decumbent primary branches. Primary branches usually fertile, slightly larger than the sterile branches, somewhat flattened to subterete, swelling somewhat above each articulation, to 5 cm in length, 0.6-2.0 mm in width at the base. Branching irregular or anisotomic dichotomous with terminal branches commonly as equal dichotomy. Upper surface grayish green, smooth, slightly convex. Cortex 45-60 μ thick, composed of thick-walled, gelatinized and fused hyphae intricated in various directions and covered by a thin (1-3 μ) colorless epicortex. Algal-medullary layer 35-55 μ thick, continuous around the entire lobe, occasionally occurring only

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only in isolated areas on the lower side; algae, protococcoid, spherical, 8-12 μ in diameter. Medulla composed of colorless, thick-walled, generally longitudinally arranged hyphae, 7.5-10.5 μ in diameter; quite dense near the algae layer, becoming looser and forming a medullary cavity toward the center. Apothecia common, 0.8-2.0 mm across, subterminal on the primary branches. Mazaedium oriented apically to more often subapically, exposed at an early stage of development by the irregular rupturing of the enclosing receptacle. Asci cylindric, near maturity 45-55 X 5-7 μ, containing 8 spores arranged in a single row. Spores spherical, grayish, 5.5-7.0 μ in diameter. Pycnidia rare in terminal areas.

Medullary reactions.--PD + orange or rarely PD -, KOH + pale yellow or rarely KOH -, KC -, C -, I -.

Constituents.--Sphaerophorin, norstictic acid (in trace amounts), stictic acid, and constictic acid. Of the thirty seven specimens examined, all were found to contain sphaerophorin. Five of eighteen collections from Japan, one of two collections from West Irian, and two of three collections from Sabah were found to contain only sphaerophorin. It was also interesting to note that three of four collections containing only sphaerophorin from Japan were from the same prefecture, suggesting possible chemically distinct populations.

Discussion

Sphaerophorus diplotypus is closely allied to *S. madagascareus*, with both species having a medullary cavity, similar spore characters, and producing the same lichen substances. _Sphaerophorus diplotypus_ can be differentiated by its more irregular branching pattern, slightly broader lobes, and terminal rather than laminal apothecia as is found in _S. madagascareus_. The medullary cavity of _S. diplotypus_ is also generally smaller with the terminal branchlets of some specimens having an essentially solid medulla.

This species is restricted to wood or bark and according to label data it seems to occur at high elevations ranging through Java, Malaya, Sabah, West Irian, Papua, Taiwan and into Japan (see Figure 51). Specimens from Japan, Taiwan, and occasional ones from Borneo are generally poorly developed, infrequently branched and have a thinner, powdery medulla surrounding the central cavity. These specimens are also rarely fertile with terminal apothecia found in only one specimen.

Material Examined

Chemotype I (Sphaerophorin, stictic acid,
and constictic acid)

Specimens seen.--MADAGASCAR. Ivohimanitra forest, _Forsyth-Major 97_ (BM). - JAVA. Talaga, 1913 _Fleischer_ (FH). - MALAYA. Pahang: along road between Gunong Brinchang and Tanah Rata, _Hale 30474_ (US), vicinity of Gunong Brinchang, _Hale 29938_ (US); Ginting Highlands, Gunong Ulu Kali, _Dransfield 412_ (BM). - SABAH. Kinabalu Nat'l. Park: open ridge between E and W Mesilau River, _Hale 29052_ (US). - TERRITORY OF PAPUA. Boridi, 1935 _Carr_ (MSC). - WEST IRIAN. Mt. Carstensz, _Kloss_ s.n. (BM). - TAIWAN. Raisha, Asahina F 273 (TNS). - JAPAN. HONSHU. Mie Pref.: 1938 Magohuku (FH), Sato 22 (FH); Wakayama Pref.: Mt. Koya, 18 April 1926, 31 Oct. 1926 Numajiri (TNS); Shizuoka Pref.: Shuchi-gun, Mt. Akiha, 1926 Asahina (TNS). KYUSHU. Kumanoto Pref.: Nichize, 1928 Maebara (TNS), Mt. Ichibusa, 1933 Fujikawa (TNS); Miyazaki Pref.: Mt. Ishido, Koyu-gun, Kurokawa 65094 (TNS). SHIKOKU. Kochi Pref.: Aki-gun, Umaji-mura, Mt. Asedani, 1931 Fujikawa (TNS), Nagaoka-gun, Mt. Shiraga, 1934 Yoshinaga (TNS). YAKUSHIMA I. Kagoshima Pref.: Kosugidani, Sato 2096a (MSC), River Nagata, 1933 Fujikawa (TNS).

Chemotype II (Sphaerophorin)

Specimens examined.--SABAH. Kinabalu Nat'l. Park, along Mesilau trail on the plateau from Mesilau River to Kundason, Hale 28179 (US), vicinity of Layang Layang, Hale 29159 (US). - WEST IRIAN. Mt. Carstensz, Kloss s.n. (BM). - JAPAN. HONSHU. Wakayama Pref. Kowadani, Owasse, Kurokawa 59031 (TNS), Mt. Koya, 10 Oct. 1933, 21 Oct. 1933 Numajiri (TNS). KYUSHU. Kumanoto Pref.: Mt. Ichibusa, Kurokawa 63092 (TNS). SHIKOKU. Kochi Pref.: Mt. Oto, 1931 Fujikawa (TNS).

7. Sphaerophorus dodgei Ohlsson, spec. nov.

Similis S. melanocarpo (Sw.) DC. sed differt ramo principali elongatiori, continvo, infrequenter ramoso; sporis 5.5-7.0 μ diam.; sphaerophorin et materia chemica ignota continente.

Type: Chile, Prov. Osorno, forest around Lago Toro on road to Refugio Antillanca, 2800 ft., Imshaug 42952 (MSC, holotype).

Nomenclatural Remarks

This previously undescribed species was included by Dodge (1969) in his description of *Pleurocybe patagonica*. The Thaxter material cited by Dodge was noted as being elongate and producing almost terminal apothecia, in contrast with the more foliose thallus and ventrally oriented mazaedia of *P. patagonica*. Dodge's description of the spores of *P. patagonica* as hyaline and 6 μ in diameter actually refers to the Thaxter material, i.e., *S. dodgei*. A photograph of the holotype material of *S. dodgei* is provided in Figure 2.

Description

Thallus corticolous, well-developed, elongate, infrequently branched, with occasional sterile basal branches. Primary branches upright, irregularly and sparsely branched, subterete to slightly compressed, to 3.5 cm in length, 0.8-1.5 mm in width. Upper surface convex, dull grayish-green, smooth, rarely with small branchlets issuing forth; lower surface light colored to sometimes discolored, occasionally with longitudinal wrinkles. Cortex composed of thick-walled, gelatinized and fused hyphae intricated in various directions and covered by a thin (2-3 μ) colorless gelatinous epicortex; upper cortex 45-80 μ thick, lower cortex 35-55 μ thick. Algal-medullary layer, 20-40 μ thick, continuous beneath the upper side occurring in occasional isolated areas on the lower side; algae spherical, protococcoid, 9-13 μ in diameter. Medulla composed of colorless, thick-walled generally longitudinally arranged hyphae, 3-5 μ in diameter, farily densely interwoven near the algae layer, becoming loose near the center. Apothecia common, 1.5-2.2 mm across, subterminal. Mazaedium oriented subterminally, exposed at an early stage of development; when mature prominent, black. Asci cylindric, near maturity, 40-50 X 5-6 μ, containing 8 spores arranged in a single row. Spores, spherical, hyaline to slightly grayish, (4.5) 5.5-7.0 (7.5) μ in diameter. Pycnidia common in terminal areas.

Medullary reactions.--PD -, KOH -, KC -, C -, I -.

Constituents.--Sphaerophorin and an unknown substance. Of the 24 specimens studied, all contained sphaerophorin and 18 contained an unknown substance (see Table 7). This substance had similar Rf values to isousnic acid in the three standard solvent systems of C. F. Culberson (1972), but when chromatogrammed in the solvent benzene on an oxalic buffer TLC sheet, it had a much lower Rf value.

Discussion

Sphaerophorus dodgei has probably been most often confused with *S. melanocarpus*, having a somewhat similar thallus morphology and similar spore characters. It can be distinguished by its farily narrow and elongate nature, infrequent branching, prominent and exposed mazaedium and unique chemistry.

This species is endemic to southern South America occurring in the Valdivian region of Chile and in the Nahuel Huapi National Park area of Argentina. It has been found growing in fairly shaded forested area on various trees including, Saxegothaea, Laurelia, and Nothofagus.

Material Examined

Chemotype I (Sphaerophorin and an unknown P- substance)

Specimens seen.--ARGENTINA. Prov. Rio Negro: Lago Frias near lake, Lamb 5983 (CAN). - CHILE. locality unknown, Krause s.n. (BM), E. C. Reed s.n. (BM); Prov. Osorno: Lago Toro, on road to Refugio Antillanca, Imshaug 42952, 42996 (MSC), quarry just above Lago Toro on road to Refugio Antillanca, Imshaug 43016, 43019 (MSC), stream in forest, above Lago Toro on road to Refugio Antillanca, Imshaug 43054 (MSC), in valley of Rio Nauto near road, between Laguna El Encanto and Lago Toro, Imshaug 43079, 43093 (MSC); Prov. Valdivia: locality unknown, Lechler 355 (BM), Cerros Los Tayos, 1929 Hollermayer (H), Huallihuapi, 11 Nov. 1931 Hollermayer (H, F), Panguipulli, Claude-Joseph 2268 (FH, US), Corral, 1905 Thaxter (FH); Prov. Chiloe: I. Chiloe, King s.n. (BM), Anderson s.n. (BM); Prov. Aisen: Puerto Aisen, 1897 Dusén (H).

Chemotype II (Sphaerophorin)

Specimens seen.--ARGENTINA. Prov. Rio Negro: Lago Frias, near Chilean Boundary, Lamb 5998 (H, CAN), Lago Nahuel Huapi, Puerto Blest, Kalela 107b (H). - CHILE. locality unknown, coll. unknown (FH); Prov. Osorno: stream in forest, above Lago Toro, Imshaug 43048 (MSC); Prov. Cautin: Volcan Llaima, Gunckel 19430 (MSC).

8. Sphaerophorus formosanus (Zahlbr.) Asah. in Mituno

J. Jap. Bot. 14: 667. 1938. Sphaerophorus melanocarpus ssp. formosanus Zahlbr. Repert. Spec. Nov. Regni Veg. 31. 206. 1933. Type: Taiwan, Asahina F 274 (TNS, isotype).

Sphaerophorus jamaicensis Räs. Anales Soc. Ci. Argent. 128: 146. 1939. Type: Jamica, 4 July 1919 C. C. Plitt (H, holotype).

Nomenclatural Remarks

The original descriptions of S. formosanus and S. jamaicensis are very similar, the former described as "fibrilose cylindrical" and the latter as "coralloid isidios," both emphasizing the isidioid nature of the primary branches. After looking through large amounts of material from both the West Indies and Japan, it is my opinion that S. jamaicensis should be placed in synonomy with S. formosanus. A photograph of the isotype in (TNS) is provided in Figure 3.

Description

Thallus corticolous, caespitose, producing numerous crowded primary branches. Primary branches upright, terete to more commonly subterete, to 2.5 (4.5) cm in length, 0.8-1.2 (2.2) mm in width near the base, becoming slightly swollen and broader above each articulation, and more terete between branches. Upper surface grayish-green, lined with numerous small (to 1.5 mm long) simple, cylindric isidioid bodies and occasional coralloid branchlets, occurring singly or in fasciculate groups, concolorous with the upper surface; lower surface light colored, plain to irregularly wrinkled to lacunose. Cortex composed of thick-walled, gelatinized and fused hyphae, intricated in various directions and covered by a thin (1-2 μ) colorless gelatinous epicortex; upper cortex of primary branches 50-70 μ thick, lower cortex 30-50 μ thick. Algal-medullary layer 15-30 μ thick, continuous along the upper side, but occurring only in occasional localized areas along the lower side; algae, protococcoid, spherical 8.0-10.0 μ in diameter. Medulla composed of colorless, thick-walled generally longitudinally arranged hyphae, 5.0-6.5 μ in diameter, fairly densely interwoven near the algae layer, but becoming somewhat more lax toward the center. Apothecia developing subterminally, 1.0-1.4 (2.5) μ across, opening early by the irregular rupturing of the surrounding receptacle to expose the mazedium which is generally oriented subterminally. Receptacle corticate occasionally with small phyllocladial branchlets. Asci cylindric, near maturity, 40-55 X 4.5-6.0 μ, containing 8 spores arranged in a single row. Spores, spherical, hyaline to grayish, 5.5-8.0 (8.5) μ in diameter, usually surrounded by a dark carbonaceous material. Pycnidia common, located in the apically area.

<u>Medullary reactions</u>.--PD + orange or rarely PD -, KOH + pale yellow, or KOH -, KC -, C -, I -.

<u>Constituents</u>.--Of the 154 specimens of <u>S</u>. <u>formosanus</u> examined only 16% were found to contain only sphaerophorin with the remaining specimens containing sphaerophorin, norstictic acid, stictic acid, and constictic acid. The type material from Taiwan contained

only sphaerophorin. It was interesting to note that of the seven specimens from Japan which contained only sphaerophorin, five of these were from Nagano prefecture. This suggests a population capable of producing only sphaerophorin which is identical in all other respects with the populations producing stictic and constictic acids.

Discussion

Sphaerophorus formosanus is easily separated from S. melanocarpus by the numerous isidiod and coralloid structures along the main branches (see Figure 4). In rare specimens the isidia may be nearly absent, then features such as its generally smaller nature and more terete branches must be relied upon. For further comments see S. melanocarpus.

This species is mainly concentrated in two general areas, Japan and the West Indies, although it is found in Central America and various other tropical and subtropical islands (see Figure 52). In Jamaica it seems to occur primarily in the high altitude forests which are areas of high precipitation (above 3100 mm annual precipitation). This species is typically corticolous, but also grows over bryophytes on bark and logs.

Material Examined

Chemotype I (Sphaerophorin)

Specimens seen.--JAPAN. HONSHU. Saitama Pref.: Chichibu Mts., Oyoka, Omura 329 (US), Chichibu, Kurokawa 520683 (TNS);

Yamanashi Pref.: Mt. Mizugaki, Kurokawa 521105 (TNS); Nagano Pref.: Mt. Kobuse, Kurokawa 59212 (MSC, US), Mt. Kobushi, Kurokawa 59195 (TNS), Mt. Eboshi, Kurokawa 520252 (TNS); Mt. Kimpu, Kurokawa 65151, 520204 (TNS). - TAIWAN. Raisha, Asahina F 274 (TNS), Asahina s.n. (US). - FERNANDO PO. Clarence Peak, Mann 681 (BM). - JAMAICA. trail to Portland Gap, 18 June 1926 Plitt (MSC). - GUATEMALA. Dept. Huehuetenango, top of Cerro Chemalito, W of Aquales Serdán, Mexico, 2 Aug. 1942 Steyermark (F, MSC). - COSTA RICA. Cerro de la Muerto, Crosby 3926 (DUKE). - PANAMA. Chiriqui, Volcan Chiriqui, 5-12 Dec. 1948 Scholander (US, F, MSC), 10 Dec. 1948 Scholander (MSC), 12 Dec. 1948 Scholander (MSC). - PERU. San Martin, Holligan L-79 (BM).

Chemotype II (Sphaerophorin, stictic acid, and constictic acid)

Exsiccati seen.--Köfar. 21 (BM, H); Malme Austro. 359 (H, MSC).

Specimens seen.--JAPAN. HONSHU. Tochigi Pref.: Ashio. 1942 Asahina (TNS); Saitama Pref.: Chichibu, Kurokawa 56121, 510053 (TNS), Mt. Mitake, 1927 Nakaji (TNS); Yamanashi Pref.: Mt. Fuji, 1934 Komiyama (TNS); Nagano Pref.: Mt. Kobuse, Kurokawa 59212 (TNS); Kanagawa Pref.: Mt. Hakone, 1925 Ogata (TNS); Shizuoka Pref.: Mt. Akiha, 1926 Asahina (TNS); Mt. Amagi, 1933 Asahina (TNS); Gifu Pref.: Mt. Ontake, Kurokawa 64055 (TNS). Aichi Pref.: Mt. Tonaka, 1948 Suzuki (US); Mt. Horaiji, Kurokawa 66021 (TNS); Wakayama Pref.: Mt. Koya, 21 Jan. 1924, 28 Jan. 1926, 7 Feb. 1926, 18 April 1926, 7 March 1926, 17 May 1926, 10 Oct. 1926, 31 Oct. 1926, 12 Nov. 1926

Numajiri (TNS), 14 Sept. 1927 Asahina (TNS), Kurokawa 56041, 57273, 60241 (TNS); Kyoto Pref.: Mt. Atago, 1943 Asahina (TNS), Mt. Hiei, Kurokawa 540386 (TNS); Hiroshima Pref.: Kuroutsu-kyo, Saiki-gun, Hale 29375 (US), Kurokawa 64422 (TNS). SHIKOKU. Tokushima Pref.: Mt. Kenzan, Inobe 11 (TNS), Katuura-gun, Inobe 79 (TNS); Kochi Pref.: Aki-gun, 13 Aug. 1931, 14 Aug. 1931, 15 Aug. 1931 Fujikawa (TNS), 1930 Yoshinaga (TNS); Ehime Pref.: Mt. Ishizuchi, Kurakawa 60053 (TNS), Mt. Sasayama, 1928 Ogata (TNS), Ogata 48 (TNS). KYUSHU. I. Yakushima, 1933 Fujikawa (TNS); Kumamoto Pref.: Mt. Ichibusa, Kurokawa 63091 (TNS); Fukuoka Pref.: Mt. Hikosan, Kurokawa 62451 (TNS); Miyazaik Pref.: Mt. Ishido, Kurokawa 65094 (TNS). Nagasaki Mt. Tara-dake, Kurokawa 62562 (TNS), I. Tsushima, Fauri 3804 (FH); I. Yaku, Omura 645 (US). - PHILIPPINES. LUZON. Benguet, Pauai, 1909 McGregor (US, FH), Leptanto, Mt. Data, Merrill 4951 (US), Hale 26388 (US). - AUSTRALIA. QUEENSLAND. on the way to the Coomera River, McPherson Range, 1951 Morris (MEL). - MAURITIUS. locality unknown, [1874-75] Balfour (BM), 1869 Peck (FH-Tuck, 3747); Vacoas, Ayres s.n. (BM); Shoulder of Pouce, 1857 Ayres (BM). - REUNION. locality unknown, Meyier [?] 60 (H-Nyl. 40347). - MADAGASCAR. S Betsileo, 1881 Hildebrandt 2784 (FH). -

JAMAICA. locality unknown, coll. unknown (BM), 1884 Hart (FH-Tuck, 3746, FH), 1905 Cummings (FH), Wilson s.n. (BM), Britton s.n. (MICH), 17 July 1926 Plitt (US); New Haven Gap Trail, 29 June 1919 Plitt (MICH, MSC); Morces Gap, Imshaug 13287 (MSC), 4 July 1919 Plitt (H), 23 June 1932 Plitt (MSC), 29 June 1932 Plitt (US); Mt. Hareb ridge, Imshaug 13144 (MSC); Catherines Peak, Imshaug 13398

(MSC); John Crow Peak, Maxon 1306 (US, FH); Sir Johns Peak, Imshaug 15192 (MSC); High Peak, Imshaug 15217 (MSC); Peak between High Peak and Main Ridge Gap, Imshaug 15200 (MSC); Main Ridge Gap, Imshaug 14742 (MSC); Mossmans Peak, Imshaug 14730, 14714 (MSC), Maxon 9637, 9772 (US); Portland Gap, Imshaug 12964 (MSC); Blue Mt. Peak, Crosley 3410 (DUKE), Imshaug 13021, 15520 (MSC), Orcutt 5358 (MSC), Maxon, Ellsworth, Killip 1105 (US, FH); East Peak, Imshaug 14837 (MSC); Sugar Loaf Mt., Imshaug 15461 (MSC). - CUBA. locality unknown, coll. unknown (US); Pico Turquino, Léon 11326 (F), Imshaug 25101, 25129 (MSC); Loma del Gato, around El Gato, Imshaug 24848 (MSC). - HAITI. Dept. du Sud., Massif de la Hotta, Pic Macaya, Wetmore 3227, 3334, 3328 (MSC), Morne Macaya, Imshaug 23197 (MSC). - DOMINICAN REPUBLIC. Cordillera Central, NW of Constanza, Imshaug 23690 (MSC); ridge between Pico del Yaque and L. Chinquela, Wetmore 3733 (MSC); Casabito, Wetmore 3418 (MSC). - MEXICO. Lagos de Mt. Bello, SE of Comitan, Hale 20440 (US). - COSTA RICA. locality unknown, Valeria 63 (US); Prov. San Jose: Cerro de las Vueltas, Standley & Valerio 43832 (FH, US), Volcan de Turrialba, Standley 35313 (FH); Prov. Heredia: Cerros de Zurqui, San Isidro, Standley 50346 (FH, US). - PANAMA. Chiriqui, Volcan Chiriqui, 5-12 Dec. 1948 Scholander (US), 5-7 Dec. 1948 Scholander (US). - VENEZUELA. locality unknown, Fendler s.n. (FH, US, MICH); Dist. Federal, El Avila, 1958 Dennis (BM).

Chemotype III (Sphaerophorin and stictic acid)

Specimens seen.--JAPAN. SHIKOKU, Kochi Pref.: Mt. Oto, 1931 Fujikawa (TNS). Asahina F 274 (TNS). - JAMAICA. New Haven Gap Trail, 29 June 1919 Plitt (US). - DOMINICAN REPUBLIC. Piquito del Yaque, Imshaug 23629 (MSC). - COSTA RICA. Volcan de Turrialba, Standley 35313 (US).

9. Sphaerophorus kinabaluensis (Sato) Ohlsson, comb. nov.

Pseudosphaerophorus kinabaluensis Sato, Misc. Bryol. Lichenol. 4: 108. 1967. Type: Borneo, Kinabalu Nat'l. Park, between Layang Layang and Paka Cave, 2700-2900 m., M. E. Hale 28656 (TNS & US, isotype).

Nomenclatural Remarks

Pseudosphaerophorus kinabaluensis was described as a new species on the basis of deeply constricted, two-celled spores unlike the one-celled spores of Sphaerophorus. The spores in the two isotype specimens have been found to be one-celled conforming to the spores of Sphaerophorus. The apothecia are described as laminal, which in fact they are, but I feel this feature is quite atypical of the material studied as most specimens placed in this taxon have subterminal apothecia. For a comparison of the type material and what I feel is typical material of this taxon see Figures 5 and 6.

Description

Thallus corticolous, with numerous crowded upright, sparsely branched fertile branches, resulting in a fastigiate appearance. Primary branches narrowly flattened or compressed, to 8 cm in length, 0.8-2.0 mm in width; secondary branches anisotomic dichotomous, sterile, usually forming near the base, becoming terete and attenuate at the terminal ends. Upper surface smooth, grayish green, convex, commonly transversely annulately cracked; lower surface light colored, and without wrinkles. Cortex composed of thick-walled, gelatinized and fused hyphae intricated in various directions and covered by a thin (1-4 μ) colorless epicortex; upper cortex of primary branches 60-100 μ thick, lower cortex 40-65 μ thick. Algal-medullary layer 20-30 μ thick, continuous beneath the upper cortex, occurring in isolated areas on the lower side; algae protococcoid, spherical, 8-10 μ in diameter. Medulla composed of thick-walled colorless, generally longitudinally arranged hyphae, 5.5-8.0 μ in diameter, partially fused and dense. Apothecia common, subterminal to rarely ventrally laminal, 1.0-2.8 mm across. Mazaedium oriented subapically, exposed at an early stage of development by the irregular rupturing of the enclosing receptacle; when mature, prominent, black. Asci cylindric, near maturity, 40-55 X 5-7 μ, containing 8 spores arranged in a single row. Spores spherical, gray, 6.5-8.5 μ in diameter, often surrounded by a dark carbonaceous material. Pycnidia common, located in the terminal areas of the branches; microconidia colorless, rod-shaped 5.0-6.0 X 1.0-1.5 μ.

Medullary reactions.--PD + orange, KOH + pale yellow, KC -, C -, I -.

Constituents.--Sphaerophorin, norstictic acid (always in trace amounts), stictic acid, and constictic acid.

Discussion

Sphaerophorus kinabaluensis is closely related to S. melanocarpus with its main distinctive features being the elongated attenuating upright sterile branches and the well-exposed, prominent mature mazaedium (see Figure 6). This species is known from Ceylon, Borneo and New Caledonia, occurring generally above 1600 meters (see Figure 53).

Material Examined

Specimens seen.--CEYLON. Pidurutalagala, 1879 Almquist (H-Nyl. 40351); central province, Thwaites C.21, C.16 (BM); Hoolankanda Peak [?], 1862 Brodie (BM). - SABAH. Kinabalu Nat'l. Park: between Layang and Paka Cave, Hale 28656 (US, TNS), W. Mesilau River, Hale 29141 (US), Mesilau trail from Layang Layang to Mesilau River, Hale 28522 (US), Kambaranga radio tower, Hale 29266, 28502 (US), E Mesilau River, Hale 29231, 28414 (US), ridge between E and W Mesilau River, Hale 28359 (US), Paka Cave, Clemens 10602 (FH). - NEW CALEDONIA. locality unknown, 1863/64 Vieillard (H, H-Nyl. 40349); Mt. Mon [?], 1908 Cacot [?] (FH, MSC), 1865 Deplanche (H-Nyl, 40360).

10. Sphaerophorus madagascareus Nyl. ex Cromb.

J. Linn. Soc., Bot. 15: 409. 1876. Pleurocybe madagascarea (Nyl. ex Cromb.) Zahlbr. Engler-Prantl. Naturl. Pflanzenfamil. I Teil Abt. 1: 86: 1903. Type: Madagascar, near Antananarin [Tananarive], W. Pool s.n. (H-Nyl. 40407, holotype; BM, isotype).

Pleurocybe hildebrandtii Müll. Arg. Flora 67: 613. 1884. Type: Madagascar, Andrangolvaka, Hildebrandt s.n. (FH, isotype).

Nomenclatural Remarks

In my opinion Pleurocybe should be included within the genus Sphaerophorus as the important differentiating characters that were given by Müller, the hollow medulla and laminal apothecia, are found in other species within the genus. Sphaerophorus diplotypus has a medullary cavity and S. kinabaluensis, as well as S. microsporus, infrequently have laminal apothecia. Excluding the laminal apothecia and possibly the medullary cavity all other important characters are in common with the subgenus Bunodophorus. A photograph of the holotype is provided in Figure 13.

Baeoderma Vain. (1921) was based on Heterodea madagascareus Nyl. (1888), a name which has apparently been confused with Sphaerophorus madagascareus Nyl. (1876). Consequently, Baeoderma Vain. has been erroneously cited as a synonym of Pleurocybe by Zahlbruckner (1922) and James and Hawksworth (in Ainsworth, 1971).

Description

Thallus corticolous, producing numerous branches of equal size and shape, interlacing with each other. Branches flattened to somewhat inflated, anisotomic dichotomous to usually equally dichotomous, 3-5 cm in length, 0.8-1.5 mm in width. Surface nitid, greenish gray, plain or without any outgrowths. Cortex 45-60 μ thick, composed of thick-walled colorless, gelatinized and fused hyphae, intricated in various directions and covered by a thin (5-8 μ) colorless epicortex. Algal-medullary layer 20-30 μ thick, continuous beneath upper cortex, usually forming in isolated areas on the lower side; algae protococcoid, spherical, 8-10 μ in diameter. Medulla composed of thick-walled, colorless, generally longitudinally arranged hyphae, 6-8 μ in diameter, fairly dense near the algae layer becoming loose producing a well-developed medullary cavity toward the center. Apothecia common, 0.6-1.0 mm in diameter, forming laminally along the lower surface. Mazaedia exposed at an early stage of development by the irregular rupturing of the enclosing receptacle; when mature, black, partially surrounded by the receptacle. Base of apothecium solid, with loosely intricated medullary hyphae. Asci cylindric, near maturity, 40-50 X 4-6 μ, containing 8 spores, arranged in a single row. Spores spherical, hyaline to gray 5.5-7.0 μ in diameter, often surrounded by a dark carbonaceous material. Pycnidia rare in terminal areas.

Medullary reactions.-- PD + orange, KOH + pale yellow, KC -, C -, I -.

Constituents.--Sphaerophorin, norstictic acid (in trace amounts), stictic acid, and constictic acid were present in the nine specimens examined.

Discussion

Sphaerophorus madagascareus is closely allied to S. diplotypus, but can be distinguished by its laminal apothecia, fairly dichotomous branching, and larger medullary cavity.

This species is known from Madagascar, occurring in forested areas at fairly high elevation. According to the label data, this species occurs between 1200 and 2000 meters on the island, which is an area of high rainfall, receiving upwards of 3000 mm of precipitation annually (Donque, 1972). These areas are rich lichenologically and are, in fact, called "lichen forests" by Koechlin (1972).

Material Examined

Specimens seen.--MADAGASCAR. near Antananarin Tananarive, Pool s.n. (H-Nyl. 40407, BM); Ambohimilombi forest, Forsyth-Major 461 (BM); Andrangolvaka, 1880 Hildebrandt (FH).

11. Sphaerophorus melanocarpus (Sw.) DC. in Lam. et DC.

Flora Franc. ed. 2, 6: 178. 1805. Lichen melanocapus Sw. Nova Genera et Spec. Plant. 147. 1788. Type: Jamaica, Swartz s.n. (S, lectotype).

Sphaerophoron australe Laur. Linnaea 2: 44. 1827. Sphaerophorus compressum var. australe Linds. Trans. Roy. Soc. Edinburgh 22: 151. 1859. Bunodophoron australe (Laur.) Mass. Mem. Imp. Reale. Inst. Veneto Sci. 10: 76. 1861. Sphaerophorus melanocapus var. australis (Laur.) Murr. Trans. Roy. Soc. New Zealand 88: 188. 1960. Type: Australia, Sieber s.n. (BM, lectotype; PC & BM isolectotype).

Dufourea flabellata Hue, Nouv. Arch. Mus. Hist. Nat. 4: 61. 1899. Type: Bolivia [Colombia], Tolima, Goudot s.n. (PC, holotype).

Nomenclatural Remarks

In his description of Lichen melanocarpus, Swartz did not designate a type specimen. I have examined two specimens of Lichen melanocapus from the Swartz herbarium, one of which I am selecting as the type specimen. This material, without locality data, has the name "melanocarpus" written by Swartz in red ink and according to Carl-Fredrik Lundevall, curator of the Swartz herbarium, this specimen is almost certainly Swartzes own collection (personal communication). The other specimen from the Swartz herbarium is a Menzies collection with the locality listed as "America Septentrionalis."

Laurer (1827) published three new species of Sphaerophorus under the genus Lichen, including S. insignis and S. australis. As these two species have not been previously typified, it has been generally assumed that S. australis represented the broadly flattened, large-spored southern hemisphere species. Sphaerophorus insignis was given subspecific ranking by a subsequent study, but it has generally been ignored as a taxonomic entity. After studying three separate fragments of the S. australis type, it was found to be morphologically and chemically identical to S. melanocarpus.

Dufourea flabellata is believed to be an enlarged, atypical form of S. melanocarpus and is so treated in this study. Several other specimens with similar features have been found and are discussed later in this paper. Although Hue cited the type material from Bolivia it is likely the original material came from Colombia. Herzog (1923), who discusses the collectors of Bolivia, has no record of Goudot and Tomlima is not in Bolivia, but is a province or volcano in Colombia.

Description

Thallus corticolous, with numerous, crowded smaller sterile, basal branches and less frequent, better-developed, fertile primary branches. Primary branches erect to decumbent, compressed, becoming subterete in secondary and terminal branchlets, to 5 cm in length, 0.7-1.4 mm in width. Upper surface slightly convex, grayish-green, nonisidiate, larger branches transversely annulate-cracked; lower surface light colored, plain to irregularly wrinkled especially near the apothecium. Cortex composed of thick-walled, gelatinized and fused hyphae intricated in various directions; upper cortex of primary branches 70-100 μ thick, lower cortex 40-60 μ thick. Algal-medullary layer 15-30 μ thick, continuous beneath the upper cortex, occurring in occasional isolated areas on the lower side; algae protococcoid, spherical, 8-10 μ in diameter. Medulla composed of thick-walled, colorless, generally longitudinally arranged hyphae, 6-8 μ in diameter, fairly dense near the algae layer becoming somewhat lax near the center. Apothecia, common, 1.2-3.5 mm across, subterminal. Mazaedium oriented subterminally to ventrally, exposed at an early stage of development by the irregular rupturing of the enclosing receptacle. Margin of receptacle often fimbriate or with small phyllocladial branchlets. Asci cylindric, near maturity, 40-50 X 5-7 μ, containing 8 spores arranged in a row. Spores spherical, grayish, 5.5-8.0 μ in diameter, often surrounded by a dark carbonaceous material. Pycnidia common in the terminal areas.

Medullary reactions.--PD + orange or PD -, KOH + pale yellow or KOH -, KC -, C -, I -.

Constituents.--Of the 423 specimens examined, nearly 88%, including the type specimen, contained sphaerophorin, norstictic acid, stictic acid and constictic acid. The other 12% contained only sphaerophorin. As found in other species of Sphaerophorus, the distribution of a particular chemotype is not random, but is located in certain geographic areas. For example, almost 50% of the specimens containing only sphaerophorin are found in the highly oceanic areas along the coast of Alaska, in the Queen Charlotte Islands, and along the British Columbia coast. From Japan, forty three specimens were examined of which six were found to contain only sphaerophorin and of these, three were from Nagano Prefecture.

Discussion

Sphaerophorus melanocarpus can be distinguished from two closely allied species, S. formosanus and S. kinabaluensis in several ways. Sphaerophorus melanocarpus produces relatively short, compressed branches, and subapical to ventrally oriented mazaedia with small gray, spherical spores. Sphaerophorus formosanus typically produces numerous short simple, cylindrical isidioid structures along its branches, a phenomenon which has not been observed in S. melanocarpus. Sphaerophorus formosanus, although overlapping S. melanocarpus in its distribution in tropical areas, has not been found to extend from the subtropics, to any degree, into either the northern or southern hemispheres. Sphaerophorus kinabaluensis produces subterete to terete, sterile, elongated attenuating basal branches, which are quite characteristic in all specimens examined. In tropical South America, including Colombia (Martin 2158; Cuatrecasas 19120, 12990; Lindig 2747, Goudot s.n.) and Peru (Bües 1604), I have found a few specimens that are rather enlarged forms of the typical S. melanocarpus. As these specimens exhibit similar spore data and chemical constituents and as I have been able to examine only a limited amount of material, I will tentatively place the specimens within S. melanocarpus.

Sphaerophorus melanocarpus is a worldwide oceanic species with specimens studied from as far north as Alaska and as far south as the magellanic region of Chile (see Figures 54 and 55). In Norway, according to Lye (1969), this species is found in areas which have from 1000 to 1300 mm annual precipitation and temperatures in winter that average about 2.5° C. In British Columbia this species is common in the Queen Charlotte Islands where the mean annual precipitation is 1250 mm and freezing temperatures are rare (Calder and Taylor, 1968). Localities where I have collected this species in British Columbia are generally areas of heavy bryophyte growth, suggesting a rainforest habitat.

Sphaerophorus melanocarpus is found on a variety of substrates, but most typically it occurs on bark or wood, forming small caespitose tufts.

Material Examined

Chemotype I (Sphaerophorin, stictic acid, and constictic acid)

Exsiccati seen.--Asah. 42 (BM); Kurok. 138 (MSC); Lind. 2747 (FH-Tuck. 3746); Malbr. 254 (MSC); Mig. 147 (MICH); Rab. 515 (FH-Tuch. 3745, MICH); Reich. & Schub. 43 (BM); Weber 289 (MSC, MICH).

Specimens seen.--CHATHAM ISLAND. locality unknown, Buchanan 5 (OTA), Buchanan s.n. (OTA). - NEW ZEALAND. locality unknown, Oldfield s.n. (FH, US); NORTH I. locality unknown, Colenso 1200 (BM), Colenso s.n. (BM); Te Aroha, Leland & Chase 275B (MSC); Mt. Tararura, Buchanan s.n. (BM); McCallum's Wood, Colenso 1509 (WELT). SOUTH I. locality unknown, Haast s.n. (MEL); Nelson: locality unknown, Haast s.n. (MEL), St. Arnaud Range, Mason 631 (OTA); Westland: locality unknown, coll. unknown 41 (BM), 8 mi. W of Turiwhate, Harris 6363A (MSC); Lake Wahapo, Harris 6323 (MSC);

Lake Wombat, Imshaug 48009 (MSC), Gillespies Cook River Road, between Tornado Creek and Whelan Creek, Imshaug 47953, 47967 (MSC), Harris 6225, 6220, 6227, 6211 (MSC); Southland: Secretary I., Murray 4055, 4053, 3995 (OTA), E of Wilmot Pass, Murray 3930 (OTA), Fiordland, Doubtful Sound, Wylie 1728/7 (BM), Fiordland, Lake Thomson, James 537/4 (BM). Malvern: Punchbowl Creek Track, Imshaug 48204 (MSC), Bealey Glacier Vista, Harris 6375A (MSC), Imshaug 48181, 48155 (MSC), Avalanche Peak Track, Harris 6438, 6448A, 6459, 6463B (MSC); Canterbury: locality unknown, 1860-61 Sinclair & Haast (BM), Port Levy, Banks Peninsula, 1896 Beckett (CAN, BM). STEWART I. Port Pegasus, Imshaug 57845 (MSC). - AUCKLAND ISLAND locality unknown, coll. unknown (BM), 1840 Hooker (FH-Tayl. 155, PC), 1854 Home (BM); South Arm, Hanfield Inlet, Imshaug 57724 (MSC); between Hooker Hills and Erebus Cove, Imshaug 56694 (MSC); Ewing I., Imshaug 65450 (MSC); Terror Cove, Imshaug 56717 (MSC); SE of Mt. Raynal, Imshaug 57343 (MSC); Sealers Creek Cove, Laurie Harbour, Imshaug 57684 (MSC); Tandy Inlet, Imshaug 57567 (MSC); Grander Inlet, Imshaug 57638 (MSC); Musgrave Inlet, Imshaug 56610, 56572 (MSC); Musgrave Harbour, Imshaug 57084 (MSC); Webling Bay, Imshaug 56875 (MSC); Lookout Pt., Imshaug 56828, 56793, 56797 (MSC); Hooker Hills, Imshaug 56671 (MSC); SE of Mt. Easton, Imshaug 56496 (MSC); Enderby I., Imshaug 56335, 56301, 56299 (MSC); Ranui Cove, Imshaug 56229, 56209, 56185, 56226 (MSC); Fineran 2096, 1684 (CANTY-U); Rose I., Imshaug 56356, 56364, 56570 (MSC); head of Smith Harbour and Norman Inlet, Imshaug 57230(2), 57247(2), 57226(2) (MSC); Cove E of Tagua Bay on W of Mt. D'Urville, Imshaug 57397

(MSC); Camp Cove, Carnley Harbour, Imshaug 56917, 56909, 56880, (MSC); North Arm, Carnley Harbour, Imshaug 57020, 57034 (MSC); Adams I., Imshaug 57095, 57446, 57439, 57157 (MSC); North Harbour, Imshaug 47781 (MSC). - CAMPBELL ISLAND. locality unknown, coll. unknown (US, BM), Poppleton S26179 (US), Filhol s.n. (PC), 1874 Filhol (H-Nyl. 40350, BM, US), 1885 Lehnert (US), 1840 Hooker (FH-Tayl. 155), Rae 5488 (BM); road to old Tucker Cove Station, Harris 4447, 4458 (MSC); S of Old Tucker Cove Station, Harris 5043, 4872 (MSC); E of Mt. Sorenson, Harris 5173 (MSC); Mt. Sorenson, Imshaug 47311, 47329 (MSC); NE of Mt. Sorenson, Harris 5123, 5132 (MSC); NW of Sorenson Hut, Imshaug 47266 (MSC); between Mt. Azimuth and Courrejolles Peninsula, Imshaug 46313 (MSC); Mt. Azimuch, Imshaug 46531 (MSC); Moubray Hill, Imshaug 46908, 46870 (MSC); S side of Perseverance Harbour, Imshaug 47160 (MSC), Harris 5291 (MSC); Paris-Menhir Saddle, Imshaug 46617 (MSC), Harris 4732 (MSC); Penguin Bay and Menhir Peak, Harris 4724 (MSC); on base of spur leading to bay opposite Dent I., Imshaug 46253 (MSC); Paris-Villarceau ridge, Imshaug 46614 (MSC); Beemen Hill, Harris 4575 (MSC); Lyall ridge, Harris 5540, 5517, 5669, 5663 (MSC), Imshaug 46200, 46143, 46215 (MSC); Mt. Lyall, Harris 4789, 4780 (MSC); Mt. Lyall pyramid, Imshaug 46472, 46461, 46478, 46496 (MSC); St. Col. Peak, Imshaug 45956 (MSC); Mt. Faye, Imshaug 47342 (MSC); Rocky Bay, Harris 5343 (MSC); Mt. Dumas, Imshaug 47006, 46995 (MSC), Harris 4995 (MSC); Mt. Fizeau, Imshaug 46797 (MSC); Mt. Honey, Harris 4955 (MSC), Imshaug 47385, 46401 (MSC); Garden Cove, Imshaug 47136, 17131 (MSC), Harris 5184, 5208 (MSC); Filhol Peak, Harris 5068, 5066 (MSC).

LORD HOWE I.: locality unknown [Gower?] s.n. (MEL), 1900 Forsyth (FH), 1883 Müller (US). - AUSTRALIA. locality unknown, coll. unknown (BM, FH-Tuck. 3747), Sieber s.n. (BM, PC); QUEENSLAND: McPherson Range, Hoogland 3149 (BM). VICTORIA: Mt. Ellery, Merratt s.n. (FH. MEL, FH-Tayl. 153). - TASMANIA.: locality unknown, coll. unknown (BM), Bufton 11 (MEL), Gunn s.n. (BM), LaBillardiere s.n. (PC), Mossman 803 (BM), Hooker s.n. (BM), Oldfield 273H (US), Oldfield s.n. (US); near King William Saddle, Bratt 756 (BM), 12 mi. SE of Waratah, Bratt 69/253 (MSC); 6 mi. SSW of Waratah, Bratt 2354 (MSC); Mt. Read, Bratt 1147 (BM); 18 mi. WSW of Maydena, Bratt 68/215 (MSC); Hartz Mts., Lake Hartz, Bratt 723 (BM); Tom Thumb Gulley, Mt. Wellington, coll. unknown 566 (BM); Table Mt., Brown 517 (BM); Waratah, coll. unknown 208 (FH); Waterfall Valley, Filson 10786b (MEL); vicinity of Forest Shute and Skree Shute, Filson 6667 (MEL); Bathurst Harbour, P. Davey, Davis 1416A (MEL); near Guilford Bratt 2354 (MEL); Cradle Mt., 1949 Morris (MEL); Strzelecki Peaks, Flinders I., Bass Strait, Filson 7130 (MEL); Hartz Hut Track, Filson 10489 (MEL); Track from Dose Lake turntable to Hanson's Peak, Filson 10733a (MEL); W of Waldhein, Filson 10382 (MEL).

JUAN FERNANDEZ. MAS A TIERRA: NE wall of El Yunque, Imshaug 37765 (MSC). - CHILE. locality unknown, Lobb s.n. (BM), 1864 Krause (H), Krause s.n. (FH-Tuck. 3747), Savatier s.n. (PC); Prov. Magallanes: Straits of Magellan, 1883 Hariot (PC), B. Halt, 1868 Cunningham (BM), Smyth Canal, 19 Nov. 1895 coll. unknown (PC-Hue); 14 Nov. 1895, coll. unknown, (PC), I. Riesco, B. Borja, Imshaug 45245 (MSC), I. Desolacion, P. Angosto, Dusén 174 (FH), B. Tuesday, Imshaug 44693 (MSC), I. Mornington, P. Alert, Imshaug 43888, 43876, 43924 (MSC), I. Wellington, P. Charrua, Imshaug 43795, 43629 (MSC); I. Williams, Imshaug 43458 (MSC), Peninsula de Brunswick, B. Fortescue, Imshaug 44916 (MSC), P. Cutter, Imshaug 39491, 39570, 39593 (MSC); Prov. Chiloe: I. Chiloe, Piruquina, 1931 Junge (H), Junge 56 (H), Cordillera San Pedro, Godley 450 (BM), I. Mulchey, P. Bullena, Imshaug 43180 (MSC); Prov. Aisen: Fiordo Tempano, Imshaug 43335, 43373 (MSC); Prov. Valdivia: locality unknown, Lechler 355 (FH), Calminachue, 1936 Hollermayer (H); Prov. Osorno: Cordillera de la Carpa, Eyerdam 10909 (BM), above Lago Torro, Refugio Antillanca, Imshaug 43053 (MSC). - ARGENTINA. I. Estados, Feb. 1787 Menzies (BM). - FALKLAND IS.: coll. unknown (BM). -

ECUADOR. Prov. Pichincha, NE de Cayambe, Acosta Solis 8180 (MSC); Prov. Catopaxi, Catopaxi, Jamison s.n. (BM). - COLOMBIA. Tolima, Goudot 35 (PC); Quindio Pass, Cordillera Central, 1876 Martin (BM). - VENEZUELA. locality unknown, [Martiz] (FH-Tuck. 3746), Fendler s.n. (MSC, MICH, FH-Tuck. 3746); Mérida, Laguna Negra, Vareschi 1000 (US). - BRITISH GUIANA.: Mt. Rorima, McConnell & Quelch 506 (BM). - COSTA RICA. Prov. San Jose, NE of Santa Maria de Data, Standley 42290 (FH, US). - GUATEMALA. Dept. Chimaltenango, Cerro de Tecpám, 1938 Standley (MSC). - CUBA.: Loma del Gato, Wright s.n. (FH-Tuck. 3746). - JAMACIA. no locality, Swartz s.n. (S), Wilson s.n. (BM), Hart s.n. (BM), 30 June 1926 Plitt (MSC); Blue Mt., 25 June 1926 Plitt (MSC), July 1932 Plitt (MICH, US), Imshaug 13848 (MSC), 8 July 1919 Plitt (MSC); ridge between Sugar Loaf and E. (Lady) Peak, Imshaug 15462 (MSC);

summit of E. (Lady) Peak, Imshaug 14838 (MSC); summit of Sugar Loaf, Imshaug 15428 (MSC); St. Andrew, on trail from Morce's Gap and St. Helen's Gap, Culberson 13798 (DUKE); Clifton Mt. Trail near Woodcutters Gap, Catherines Peak, Imshaug 13566 (MSC); Sir John, 1900 Johnson (MICH). - BRITISH COLUMBIA. locality unknown, 1787 Menzies (US); VANCOUVER I.: Ucluelet, 1909 Macoun (BM, CAN), N of Kennedy Lake, NE of Ucluelet, Ohlsson 1134 (MSC); Burke Channel, Kwatna Inlet, Ohlsson 2061 (MSC); Douglas Channel, Hartley Inlet, Ohlsson 2450 (MSC). - ALASKA. locality unknown, Lehnert s.n. (MICH), 1867 Kellogg (FH-Sprague). -

IRELAND. N of Ireland, Drummond s.n. (FH-Tayl. 154); halfway house to Killarney, coll. unknown (FH-Tayl. 153); Mayo Co., Lomsbury, 1909 Knowles (US). - SCOTLAND. locality unknown, 1841 Tuckerman (FH-Tuck, 3745). - WALES. Merioneth, Jones & Rhodes 2105 (FH). - GERMANY. Lippe, 1923 Hillman (MSC, FH); Im Meissiner hochlande, coll. unknown (MICH). - FRANCE. VILLENEUVE: coll. unknown (FH-Tayl. 147); MANCHE: Cherbourg, coll. unknown (FH); MORBIHAN: forét du Conveau, coll. unknown (FH). - CZECHOSLOVAKIA. Bohemia, 1918 Kutak (FH). - NORWAY. HORDALAND: Moster, 1915 Haavas & Lynge (FH, MICH), Sveio, Drange, 1947 Ahlner (TNS), Os, Sornes, 1947 Ahlner (TNS).

SAINT THOMAS. locality unknown, 1885 Moller (H-Nyl. 40353), 1885 Newton (H), Newton 9 (H-Nyl. 40356). - TANZANIA. Kilimanjaro region, Bigger 2219, 2089 (BM). - PHILIPPINES. vicinity of Tanculan, Subprov. Mindanao, 1916 Fenax (FH). - TAIWAN. Mt. Arisan [Ali Shan], 1935 Ogata (TNS). - JAPAN. Prefecture unknown, Kadoma-guchi, Mt. Hayachine, Kurokawa 59261 (TNS); KYUSHU. locality unknown, coll. unknown (FH); Oita Pref.: Mt. Yuku-dake, Kurokawa 62251 (TNS); Kagoshima Pref.: I. Yakushima, 1933 Fujikawa (TNS); Kumamoto Pref.: Mt. Ichibusa, 1928 Maebara (TNS), 1933 Fujikawa (TNS), Hitoyoshi, 1900 Faurie (FH). SHIKOKU. Ehime Pref.: Mt. Ishizuchi, Kurokawa 60052 (TNS), Mt. Isizuit, 1933 Fujikawa (TNS); Kochi Pref.: Mt. Shiraga-yama, 1955 Inoue (TNS), Mt. Oto, 1931 Fujikawa (TNS), Takeyasiki, 1931 Fujikawa (TNS). HONSHU. Tochigi Pref.: Konsei Pass, 25 July 1930 Asahina (TNS), Ashio, 1942 Asahina (TNS); Chiba Pref.: Makawa Pass, 1936 Asahina (TNS), Mt. Ken-zan, 1934 Asahina (TNS); Nagano Pref.: Takaki 17 (TNS), Mt. Nishikomagatake, 1926 Asahina (TNS), Mt. Kitayokodake, Kurodawa 58336 (TNS), trail from Mt. Kobushi to Kobushi, Kurokawa 540278 (TNS), trail from Jumonji Pass to Mt. Kobushi, Kurokawa 520900 (TNS); Gifu Pref.: Mt. Ontake, Kurokawa 64141 (TNS); Shizuoka Pref.: Mt. Kamiyama, Kurokawa 58042 (TNS), Mt. Fuji, 1934 Asahina (TNS), 1934 Komiyama (TNS), Mt. Amagi, 1924 Asahina (TNS), Mt. Ashitaka, 1933 Asahina (TNS); Wakayama Pref.: Mt. Koya, 1926 Numajiri (TNS); 1924 Numajiri (TNS), Nara Pref.: Mt. Odaigahara, 1924 Amou (TNS); Yamagata Pref.: Mt. Funagata, 1935 Shaji (MSC). HOKKAIDO. Mt. Furano, Kurokawa 65404 (TNS).

Chemotype II (Sphaerophorin)

Exsiccati seen.--Anzi Lang. 422 (BM, FH); Lind. 2747 (BM, H-Nyl. 565).

Specimens seen.--PERU. locality unknown, Bües 1543 (FH); Tambo de Vaca, Bryan 590 (FH, F); San Martin, Holligan L-47, L-54

(BM); Cuzco, Bües 1604 (FH). - ECUADOR. Prov. Catopaxi, Catopaxi, Jamison s.n. (BM). - COLOMBIA. Tolima, Goudot 35 (PC); Dept. Cauca, Cordillera Central, Las Casitas, Cuatrecasas 19120 (MSC); Dept. del Valle, Cordillera Occidental, Los Farallones, Cuatercasas 17990 (US). - VENEZUELA. Mérida, Laguna Negra, Vareschi 1000 (F), Dennis 1948 (BM); Sierra Nevada, Dennis 1817 (BM). - BRITISH COLUMBIA. locality unknown, coll. unknown (FH-Tuck. 3739); VANCOUVER I.: W coast, Macoun 47 (FH), N of Kennedy Lake, NE of Ucleulet, Ohlsson 1119 (MSC); QUEEN CHARLOTTE IS.: Graham I.: Van Inlet, Brodo 10202 (CAN), Langara I., Brodo 10647 (CAN), Port Lewis, Brodo 10470 (MSC, CAN); Moresby I.: Bigsby Inlet, Brodo 12016 (CAN), Gowing I., Brodo 12849 (CAN), Portland Bay, Brodo 14080 (CAN, MSC), Botany Inlet, Brodo 14339 (CAN), Lyell I., Brodo 11910 (CAN). - ALASKA. locality unknown, 1867 Kellogg (FH-Sprague, US); Russian America, Kellogg 5 (FH-Tuck. 3739).

FRANCE. FINISTERE: St. Herbot, Santesson 10246 (MSC). - GERMANY. Saxony, 1842 Kunze (FH-Tuck. 3745). - REUNION. locality unknown, coll. unknown (H-Nyl. 568). - PHILIPPINES. Mt. Pulog Prov. of Benguet, Luzon, Merrill 6425 (US); vicinity of Tanculan, subprov. Mindanao, 1916 Fenax (FH). - TAIWAN. Mt. Rarasan, 1934 Suzuki (TNS). - JAPAN. HONSHU. Nagano Pref.: Mt. Kiso-Komagatake, Koidzumi 71569 (TNS), Mt. Komagatake, coll. unknown (TNS), Mt. Shirouma, Matsushima 94 (TNS); Shizuoka Pref.: Fujisan, Culberson 11112 (DUKE); Saitama Pref.: Mt. Kumotori, Chichibu, Kurokawa 510303, 50410 (TNS); Yamanashi Pref.: Shogen Pass, Chichibu Mts., Kurokawa 521273 (TNS).

Sphaerophorus melanocarpus ssp.
hawaiiensis Ohlsson ssp. nov.

Similis Sphaerophorus melanocarpo (Sw.) DC. sed rami teretes, uitidi brunneique effereus.

Type: Hawaii, island of Kauae, on Kaholuamonoa, above Waimea, A. A. Heller 2813 (MSC, holotype; US, MSC, BM, H, isotypes).

Description

Thallus corticolous, caespitose, producing close, erect to decumbent branches. Primary branches to 3 cm in length, 0.8-1.5 (2.0) mm in width; compressed basally becoming terete terminally, producing irregularly divided secondary branches. Surface nitid, brown, without phyllocladial branchlets. Cortex composed of thick-walled, gelatinized and fused hyphae intricated in various directions and covered by a thin (1-3 μ) colorless epicortex. Algal-medullary layer 20-35 μ thick, continuous and completely encircling the medulla; algae protococcoid, spherical, 6.5-10.5 μ in diameter. Medulla composed of thick-walled, colorless, generally longitudinally arranged hyphae, 4-6 μ in diameter, partially fused, producing a dense central strand. No fertile specimens were seen.

Medullary reactions.--PD + orange, KOH + pale yellow, KC –, C -, I -.

Constituents.--Sphaerophorin, norstictic acid (in trace amounts), stictic acid, and constictic acid. In the seven specimens studied, sphaerophorin was found to be present in extremely trace amounts. Stictic and constictic acids were also found in all specimens, but again, in variable concentrations.

Sphaerophorus melanocarpus ssp. hawaiiensis is known from only seven specimens, all collected by Heller on the island of Kauai in the Hawaii Islands. The thallus is characterized by terete, shiny brown branches unlike that found in the typical S. melanocarpus (see Figure 10). Fieldwork and fertile material would be helpful to fully evaluate the taxonomic ranking given to this taxon.

Material Examined

Specimens seen.--HAWAII. Kauai, on Kaholuamanoa, above Waimea, Heller 2813 (MSC, US, BM, H), 1895 Heller (FH).

12. Sphaerophorus microsporus Ohlsson ssp. nov.

Thallus ramis principalibus 1.0-2.5 cm longis, 0.8-1.5 mm latis et ramulis brevibus complanatis isidioidis prope apothecia. Sporae griseae, globosae, 5.5-6.5 μ diam. Sphaerophorin et acidum protocetraricum contineus.

Type: New Zealand, South Island, Westland, 8.1 mi. W of Turiwhate, Imshaug 48120 (MSC, holotype). (See Figure 11.)

Description

Thallus corticolous, producing several small generally erect and fertile branches and numerous short sterile branches crowded at the base. Primary branches short to 2.5 cm in length, 0.8-1.6 mm in width, subterete to flattened. Upper surface smooth, greenish gray to greenish grayish yellow, commonly with a few short dentate or flattened isidioid branchlets occurring toward the apex, lower surface light colored, smooth or sparcely irregularly wrinkled. Cortex composed of thick-walled, gelatinized and fused hyphae intricated in various directions and covered by a thin (1-3 μ), colorless, epicortex; upper cortex of primary branches 45-70 μ thick, lower cortex 40-60 μ thick. Algal-medullary layer 15-30 μ thick, continuous beneath the upper cortex, but occurring rarely or not at all above the lower cortex; algae protococcoid, spherical, 8-10 μ in diameter, generally distinct from each other. Apothecia common, subterminal, 1-2 mm in diameter. Mazaedium oriented subterminally, becoming exposed at an early stage of development by the irregular apical rupturing of the enclosing receptacle; when mature prominent, black, and globose. Asci cylindric, near maturity 40-50 X 4.5-6.0 μ, containing 8 spores arranged in a row. Spores spherical, grayish, 5.4-6.8 μ in diameter, commonly surrounded by a black carbonaceous material. Pycnidia common in apical areas.

Medullary reactions.--PD + red, KOH -, KC -, C -, I -.

Constituents.--Sphaerophorin and protocetraric acid were found in all specimens examined.

Discussion

This species is known from only seven collections, from South Island, New Zealand and from the Auckland Islands. The most distinguishing characters are the small nature of the thallus, the location of the apothecia, the small spores, and the isidioid structures along the upper surface near the apothecium (see Figure 12). The flattened branches and presence of protocetraric acid would place this species in the subgenus Aghimus, although the more apically oriented mazaedia and the small grayish spores suggests an affinity with subgenus Bunodophorus.

Material Examined

Specimens seen.--NEW ZEALAND. SOUTH I. Nelson: St. Arnaud Range, Mason 632 (OTA), Pelorus Bridge, Mason 580 (OTA); Westland: W of Turiwhate, Imshaug 48120 (MSC); Southland: Secretary I., Murray 3978, 3996, 3992 (OTA). - AUCKLAND ISLAND. Granger Inlet, Imshaug 57640 (MSC).

13. Sphaerophorus ramulifer Lamb

Farlowia 4: 426. 1955. Type: Argentina, Patagonia, Rio Negro, near Lago Frias, I. M. Lamb 5977 (CAN, holotype; FH & H, isotypes).

Sphaerophorus melanocarpus var. melanocarpus f. ramosissimus Murr. Trans. Roy. Soc. New Zealand 88: 188. 1960. Type: New Zealand, South Island, Southland, Secretary I., Murray 4052 (BM, holotype; BM, isotype).

Sphaerophorus melanocarpus var. australis f. delicatus Murr. Trans. Roy. Soc. New Zealand 88: 190. 1960. Type: New Zealand, North Island, Puketitiri, Dec. 1958 Clark [Murray 4295] (OTA, holotype).

Nomenclatural Remarks

Sphaerophorus ramulifer has been found to be a very morphologically plastic species progressing from thick, sparsely branched specimens to very thin, heavily coralloid specimens. Murray described two very similar forms based on this variability, which I consider of no taxonomic significance. A photograph of the holotype of *S. ramulifer* is provided in Figure 17.

Sphaerophorus isousnica Sato should probably be placed in synonomy with *S. ramulifer*, but as the material was unavailable for study no taxonomic judgment can be made at this time.

Description

Thallus caespitose, variable in size, forming small to large compact cushions on rocks or on trunks and branches of trees. Primary branches erect, occasionally fertile, 2-4 cm in length, 0.8-2.0 mm in width, irregularly branched with numerous coralloid or phyllocladial ramuli along the branch and surrounding the base. Surface smooth, yellowish green, occasionally transversely annulate-cracked in larger branches. Cortex of primary branches 80-110 μ thick, composed of thick-walled, gelatinized and fused hyphae, intricated in various directions, and covered by a thin (2-4 μ), colorless epicortex. Algal-medullary layer 60-90 μ thick, continuous beneath the cortex, occasionally occurring only in localized areas on the lower side; algae protococcoid, spherical, 7-10 μ in diameter. Medulla composed of thick-walled, colorless, longitudinally arranged hyphae, 4.0-6.5 μ in diameter, generally dense and closely intricated.

Apothecia occasional, 1-3 mm across, developing subterminally, opening at an early stage of development by the irregular apical rupturing of the enclosing receptacle. Receptacle corticate with occasional small phyllocladial ramuli forming along the margin. Mazaedium oriented apically to more frequently subapically. Asci cylindric, near maturity, 45-60 X 4-7 μ, containing 8 spores arranged in a row. Spores grayish to hyaline (7.5) 8.0-9.5 (10.0) μ in diameter, often covered by a dark carbonaceous material. Pycnidia common in the terminal areas.

Medullary reactions.--PD + orangish or PD -, KOH + pale yellowish or KOH -, KC -, C -, I -.

Constituents.--Isousnic acid, sphaerophorin, norstictic acid (in trace amounts), stictic acid, constictic acid and an unknown substance referred to as the "Coccotrema" unknown. *Sphaerophorus ramulifer* includes several chemotypes, three of which are of the additive type producing constictic acid, or stictic and constictic acids in addition to isousnic acid and sphaerophorin, or producing only the constant components isousnic acid and sphaerophorin. The final chemotype is the substitution type, in which the "Coccotrema" unknown replaces stictic and constictic acids. In Campbell Island over 62% of the 27 specimens and 86% of the 23 specimens from the Auckland Islands contain this substance.

Chemotype I

Sphaerophorin and isousnic acid (see Figure 56). Nearly 54% of the specimens, including the type specimen, contained these two substances with nearly 90% of the specimens from southern Argentina and from New Zealand being of this chemotype.

Chemotype II

Sphaerophorin, stictic acid, norstictic acid (in trace amounts), constictic acid, and isousnic acid (see Figure 57). Approximately 17% of all specimens contained the above substances, but in the Falkland Island 64% of the specimens displayed these same lichen products.

Chemotype III

Sphaerophorin, constictic acid, and isousnic acid. Fourteen percent of all specimens examined contained these substances, although in Chile approximately 50% of the plants were of this chemotype.

Chemotype IV

Sphaerophorin, "Coccotrema" unknown and isousnic acid (see Figure 58). This chemotype is relatively restricted in its distribution with 62% of the 27 specimens in Campbell Island and 86% of the 21 Auckland Island specimens containing these substances. A few New Zealand specimens are also of this chemotype.

As has been found in several other species of *Sphaerophorus* (i.e., *S. globosus*, *S. fragilis*), *S. ramulifer* contains several distinct chemotypes which, in my opinion, can not be separated morphologically. It is interesting that these chemotypes have rather definite and distinct distribution patterns, as has also been found in other species. Although the distribution patterns of the chemotypes do overlap, the populations of a specific site are usually similar in chemistry.

Discussion

Sphaerophorus ramulifer has several distinctive characteristics, including its generally very coralloid nature, its average spore size, and probably most importantly, the yellow color of the thallus due to the presence of isousnic acid in the cortex. It is placed within the subgenus *Bunodophorus*, and although the spores are larger than the normal *Bunodophorus* spore, they are similar in shape and color.

Sphaerophorus ramulifer is a widespread oceanic southern hemisphere species, occurring from New Zealand to southern South America. It is likely that this species is largely dependent on dispersal by means of the corralloid or phyllocladial ramuli, as only 27% of the specimens could be found with fertile apothecia. This species occurs in a variety of substrates including the bark of trees and on logs, as well as on soil and rock.

Material Examined

Chemotype I (Sphaerophorin and isousnic acid)

Specimens seen.--CHATHAM ISLAND. locality unknown, *Travers* s.n. (BM). - NEW ZEALAND. NORTH I. locality unknown, *Colenso* s.n. (BM), *Colenso 4658*, *1691* (BM); Ball's Clearing, Hawkes

Bay, Clark s.n. [Murray 4295] (OTA); road to Tarawera, Colenso 3843 (WELT, BM); Ruahine, Colenso 2711 (WELT); Whakapapa Tongariro Nat'l. Park, 1966 Wade (BM); Hawera, Colenso 2718 (WELT); Ruamahanga River, Colenso 2171 (WELT). SOUTH I. locality unknown, Haast s.n. (MEL); Nelson: Lake Rotoiti, Scott 362 (OTA), W of Rahu Saddle, Imshaug 55857 (MSC), W side of Lewis Pass, Imshaug 55708A (MSC); Westland and Otago boundary: Haast Pass, 1959 Robertson (OTA); Otago: Akatore Gorge, Murray 3724 (OTA), Trotters Gorge, Murray 3849 (OTA), Maungatua, Murray 01170 (OTA), Leith Valley Saddle, Dunedin, Murray 3547 (OTA), Mt. Cargill, Murray 01028 (OTA), Pulpit Rock, Silver Peak, Murray 4285 (OTA), Matukituki, 1957 Smiths (OTA), Lake Ohau, Murray 1853 (OTA), Mason 328, 333 (OTA), Aspiring Peak, 1968 Mark (OTA); Malvern: Arthur's Pass, Billings N2L46 (OTA), Avalanche Peak Track, Harris 6458 (MSC), Punchbowl Creek, Arthur's Pass, Imshaug 58197, 48228 (MSC), Bealey Glacier Vista, Imshaug 48144 (MSC), Harris 6380, 6384 (MSC); Canterbury: mid Roulter Valley [?], Scott 71, 70 (OTA); Southland: Main Divide, Hollyford-Eglinton Valleys, Imshaug 58057 (MSC), Wilmot Pass, Murray 3937, 3932 (OTA), The Forkes, Imshaug 58035 (MSC), Secretary I., Murray 4052 (BM), 4054 (OTA). - AUCKLAND ISLAND. locality unknown, 1840 Hooker (BM); Mt. D'Urville, Imshaug 57363 (MSC). - CAMPBELL ISLAND. W end of Lyall ridge, Imshaug 46211, 46182, 46134 (MSC), Harris 5674 (MSC); Mt. Lyall pyramid, Imshaug 46512 (MSC); between Mt. Azimuth and Courrejolles Peninsula, Imshaug 46328 (MSC); Moubray Hill, Imshaug 46932 (MSC); Menhir Peak, Imshaug 46275 (MSC). - TASMANIA. locality unknown, Archer s.n. (BM), Gunn s.n. (BM); Tom Thumb Gully, Mt. Wellington, Bratt 567 (BM); Mt. Victoria, ENE of Launceston, Bratt 70/1359 (MSC). - AUSTRALIA. VICTORIA. Blue Range near Marysville, Filson 4997 (MEL).

FALKLAND ISLANDS. locality unknown, coll. unknown (BM), Hooker 20 (BM, FH-Tayl. 150); E. FALKLANDS.: Port William, Lechler 74 (BM), Mt. Usborne, Imshaug 39893 (MSC); W. FALKLANDS.: Hill Cove, Imshaug 41003, 40970 (MSC), Weddell I., Imshaug 42025 (MSC); Fox Bay, Imshaug 42173 (MSC). - ARGENTINA. Prov. Rio Negro: Lago Frias, Lamb 5977 (CAN, FH, H), 6001 (CAN, FH), Kalela 102e, 103e (H), Lago Nahuel Huapi, Kalela 97b, 109a (H); Prov. Santa Cruz: Cerro Mayo, Miles & James 1521 (BM); I. Grande: B. Buen Suceso, Imshaug 50055 (MSC), B. Valentin, Imshaug 50444 (MSC); I. de los Estados: P. Hoppner, Imshaug 53800, 53827 (MSC), B. Crossley, Imshaug 50812 (MSC), P. Roca, Imshaug 51160, 51124 (MSC), P. Basil Hall, Imshaug 51287 (MSC), B. Primera, Imshaug 52298 (MSC), P. Cook, Imshaug 51452, 51615, 51593, 51715, 51704 (MSC), P. Vancouver, Imshaug 52063, 52071, 52049, 52205 (MSC), P. San Juan, Imshaug 51735, 51778 (MSC), P. Parry, Imshaug 53867, 54030 (MSC), P. Celular, Imshaug 52468, 52608, 52544, 52473, 53595 (MSC), B. Capitan Canepa, Imshaug 53124, 52883 (MSC), Cabo San Bartolome, Imshaug 53167 (MSC), B. Flinders, Imshaug 53309, 53445 (MSC). - CHILE. locality unknown, Poeppig s.n. (FH-Tuck. 3746); Prov. Magallanes: Cape Horn, 1942 Hooker (FH-Tayl. 154), I. Hermite, Hooker 27 (FH-Tayl. 157, BM), P. Cutter, Imshaug 39379, 39652 (MSC), P. Bueno, Imshaug 44612 (MSC), I. Chatham, E of B. Wide, Imshaug

44317 (MSC), P. Eden, I. Wellington, 1868 Cunningham (BM); Prov. Aisen: Fiordo Tempano, Imshaug 43315 (MSC); Prov. Bio-Bio: Cerro Antuco, Poppig s.n. (pc). - JUAN FERNANDEZ. locality unknown, Hooker [?] s.n. (FH-Tayl. 153). MAS A TIERRA. locality unknown, Bertero 1611 (PC); C. Salsipuedes, Imshaug 38098 (MSC); El Yunque, above Plazoleta del Yunque, Imshaug 37727 (MSC). MAS A FUERA. E rim of Los Inocentes, Imshaug 37455B, 37487A, 37487B, 37432, 37455A (MSC); S summit of Los Inocentes, Imshaug 37405, 37412B (MSC).

Chemotype II (Sphaerophorin, stictic acid, constictic acid, and isousnic acid)

Specimens seen.--NEW ZEALAND. SOUTH I. Otago: Silver Peak, Murray 4286 (OTA); Southland: Secretary I., Murray 4052 (BM). - AUCKLAND ISLAND. locality unknown, 1840 Hooker (BM). - CAMPBELL ISLAND. Mt. Faye, Imshaug 47345, 47353 (MSC). - TASMANIA. locality unknown, Oldfield s.n. (FH); Hartz Mt. Nat'l. Park, Filson 10488 (MEL); Cradle Mt. Nat'l. Park, Filson 10787, 10852 (MEL); Mt. Solitary, Filson 10430 (MEL); 14 mi. WNW of Maydena, Bratt 70/1259 (MSC); Mt. Victoria, ENE of Launceston, Bratt 70/1339 (MSC); Wakefield Valley, S of Burnie, Bratt 3693b (MSC); near Hansen's Peak, S of Burnie, Bratt 67/578 (MSC). -

FALKLAND ISLANDS. E. FALKLANDS.: Tumbledown Mt., Imshaug 39668, 39284, 39660 (MSC), Sapper Hill, Imshaug 39767, 39797, 39799 (MSC), Two Sisters, Imshaug 40400, 40359 (MSC), Mt. Kent, Imshaug 40425 (MSC), Goat Ridge, Imshaug 41537 (MSC), Engineer Point, Imshaug 40607, 40654 (MSC), Port William, Lechler 74 (BM, FH), Mt. Usborne, Imshaug 39860, 40160 (MSC); W. FALKLANDS.: Weddell I., Imshaug 41984, 42020 (MSC). - ARGENTINA. I. de los Estados: P. Hoppner, Imshaug 53747 (MSC), P. Parry, Imshaug 54013 (MSC), P. Celular, Imshaug 52591 (MSC), B. Capitan Canepa, Imshaug 53085, 52989 (MSC), B. Flinders, Imshaug 53530 (MSC). - CHILE. Prov. Chiloe: P. Ballena, I. Mulchey, Imshaug 43197 (MSC). - JUAN FERNANDEZ. MAS A TIERRA. on C. Chifladores, Imshaug 38065 (MSC).

Chemotype III (Sphaerophorin, constictic acid, and isousnic acid)

Specimens seen.--TASMANIA. near Pine Lake, SSW of Deloraine, Bratt 68/71B (MSC); Goat Hills, Oldfield 272 (FH, BM, US). - FALKLAND ISLANDS. locality unknown, coll. unknown (H-Nyl. 567). - CHILE. Prov. Magallanes: Cape Horn, 1842 Hooker (BM), Sholl Bay [B. Morris], Hariot 53 (PC), Caleta Amalia, Fiordo Peel, Imshaug 44444, 44463 (MSC), I. Juan, Bahia Wide, Imshaug 44219, 44221, 44243 (MSC), I. Chatham, E of B. Wide, Imshaug 44324, 44276, 44352 (MSC), P. Charrua, I. Wellington, Imshaug 43633 (MSC); I. Williams, B. Tribune, Imshaug 43400, 43421, 43428 (MSC); Prov. Aisen: P. Island, Peninsula Swett, Imshaug 43289, 43296 (MSC), Fiordo Tempano, Imshaug 43337, 43378 (MSC); Prov. Chiloe: P. Ballena, I. Mulchey, Imshaug 43133, 43147 (MSC); Prov. Osorno: Refugio Antillanca, Imshaug 43100 (MSC).

Chemotype IV (Sphaerophorin, "coccotrema" unknown, and isousnic acid)

Specimens seen.--NEW ZEALAND. NORTH I. Dannevirke, Colenso 1510 (WELT); Wainaropa [?], coll. unknown (OTA); Ruamahanga River, Colenso 2621 (WELT). SOUTH I. Nelson: E of Hanmer Springs Junct., Imshaug 55916A (MSC); Malvern: Bealey Glacier Vista, Harris 6375B (MSC). - AUCKLAND ISLAND. Cloudy Peak, Imshaug 57539, 57544 (MSC); peak just S of Mt. Easton, Imshaug 56613, 56631 (MSC); ridge SE of Mt. Easton, Imshaug 56515 (MSC); Mt. Raynal, Imshaug 57297, 57290 (MSC); Mt. D'Urville, Imshaug 57374, 57385 (MSC); Mt. Eden, Imshaug 57520, 57504 (MSC); Hooker Hills, Imshaug 56665, 56685 (MSC); Adams I., Imshaug 57114, 57119, 57127, 56978, 56953 (MSC). - CAMPBELL ISLAND. locality unknown, 1840 Hooker (FH-Tayl. 155); St. Sol. Peak, Imshaug 45932, 45917, 45914 (MSC); W end of Lyall ridge, Imshaug 46168 (MSC), Harris 4793, 4786, 5544 (MSC); Mt. Honey, Imshaug 46390 (MSC), Harris 4943 (MSC); Mt. Dumas, Harris 4987 (MSC), Imshaug 46959 (MSC); Mt. Azimuth, Imshaug 46578 (MSC); Moubray Hill, Imshaug 46935 (MSC); E of Mt. Sorenson, Harris 5148 (MSC); Filhol Peak, Harris 5050, 5882 (MSC).

Subgenus AGHIMUS Ohlsson, subg. nov.

Thallus ramis late complanatis; apothecia subterminalia; mazaedia ventralia; sporeae brunneae, globosae, 8-15 μ diam.

Type species: Sphaerophorus insignis Laur.

Consisting of seven species, this subgenus is easily recognized by its broadened foliose nature, reaching its greatest development in *S. scrobiculatus*, which is also the only species in the genus which does not produce sphaerophorin. Four species, *S. insignis*, *S. murrayii*, *S. patagonicus* and *S. scrobiculatus* are found to produce large spores (12-15 μ in diam.) while *S. macrocarpus*, *S. imshaugii*, and *S. coomerensis* produce spores that are smaller, being 8-10 μ in diameter. This subgenus is basically restricted to the southern hemisphere, although *S. murrayii* does reach into the northern hemisphere in Hawaii and North Borneo (see Figure 39).

14. *Sphaerophorus coomerensis* Ohlsson, spec. nov

Similar to *Sphaerophorus imshaugii* Ohls. sed ramis principalibus longioribus, 1.5-2.2 cm longis, 1.0-1.5 mm latis; apotheciis angustioribus 1-1.5 mm diam.; sporis 7.5-9 μ diam.

Type: Australia, Queensland, on the way to the Coomeras River, McPherson Range, 1951 *Morris* (MEL, holotype).

Description

Thallus caespitose, corticolous, with crowded subimbricate branches. Primary branches flattened 1.5-2.5 cm in length by 1.0-2.5 mm in width, decumbent to horizontal with occasional sterile secondary branches occurring irregularly along the larger fertile branches or around the base of the main stems. Upper surface smooth, brownish green, convex; lower surface brownish white, smooth. Cortex composed of thick-walled, gelatinized and fused hyphae intricated in various directions; upper cortex 70-100 μ thick, lower cortex 55-70 μ thick. Algal-medullary layer 25-35 μ thick, continuous between the upper cortex and the medulla; algal cells protococcoid, spherical 8-10 in diameter. Medulla composed of thick-walled colorless, loosely intricated and longitudinally arranged hyphae, 5.0-8.0 μ in diameter. Apothecia common, subterminal, 1.0-1.5 mm across. Mazaedium subterminal, becoming exposed at an early stage of development; when mature, prominent, black. Asci cylindric, near maturity 40-55 X 4.5-7.0 μ, containing 8 spores arranged in a single row. Spores spherical, brownish, 6.5-10.0 μ in diameter. When mature, usually surrounded by a dark carbonaceous material. Pycnidia occasional, occurring in the terminal areas of the branches.

Medullary reactions.--PD + red, KOH -, KC -, C -, I -.

Constituents.--Sphaerophorin and protocetraric acid was found in all specimens examined.

Discussion

This species is similar to *S. imshaugii*, but is more frequently branched and is narrower and more elongate. The small brown spores (6.5-10.0 μ) will separate this species from all other species containing protocetraric acid, except for *S. imshaugii*.

The collections studied were all on bark. At the present time *S. coomerensis* is known only from Queensland, Australia.

Material Examined

Specimens seen.--AUSTRALIA. QUEENSLAND. locality unknown, Wilson s.n. (MICH), on the way to the Coomera River, McPherson Range, 1951 Morris (MEL), Toowoomba, Hartmann s.n. (MEL).

15. Sphaerophorus imshaugii Ohlsson, spec. nov.

Thallus ramis principalibus erectis, 1.0-1.5 cm longis et 0.8-3.5 mm latis. Apothecia lata, 1.3-4.0 mm latis. Sporae brunneae, globosae, 6.5-9.0 μ diam. Sphaerophorin et acidum protocetraricum contineus.

Type: Argentina, Isla de los Estados, Bahia Primera, on W side of lake behind inner bay, sea level, Imshaug 52368 (MSC), holotype) (see Figure 9).

Description

Thallus corticolous with numerous small, crowded, sterile branches and occasional longer fertile branches occurring together. Branches irregularly flattened to subterete, erect to 1.5 cm in length, 1.0-2.2 mm in width. Upper surface smooth, brownish to grayish-brownish-yellow, with parasitic algae often covering the region around the apothecium; lower surface light gray to white. Cortex composed of thick-walled, gelatinized and fused hyphae intricated in various directions; upper cortex 80-120 μ thick, lower cortex 60-80 μ thick. Algal-medullary layer 20-30 μ thick, continuous between the upper cortex and the medulla, in subterete branches the algal layer may nearly encircle and central medulla; algal cells protococcoid, spherical, 8-10 μ in diameter. Medulla composed of thick-walled colorless, loosely intricated and longitudinally arranged hyphae 5.5-8.0 μ in diameter. Apothecia common, subterminal, 1.5-4.0 mm across. Mazaedium subterminal to ventral becoming exposed at an early stage of development by the irregular rupturing of the surrounding receptacle; when mature, prominent, black, and globose. Asci cylindric, near maturity, 35-55 X 5-7 μ, containing 8 spores arranged in a single row. Spores spherical, brown to grayish brown, 6.5-9.5 μ in diameter; when mature, usually surrounded by a dark carbonaceous material. Pycnidia common, forming at the terminal areas of the branches.

Medullary reactions.--PD + red, KOH -, KC -, C -, I -.

Constituents.--Sphaerophorin and protocetraric acid was found in all specimens studied.

Discussion

This species is quite similar to *S. coomerensis*, both species having a relatively small nature, terminal to subterminal mazaedia, identical lichen substances, and small spores. *Sphaerophorus coomerensis* differs mainly in its more frequent branching, its more narrow and elongate ramuli, and smaller apothecia.

Sphaerophorus imshaugii is known from 19 collections, with specimens seen from southern South America and the Auckland Islands (see Figure 60). It has been found growing on the bark of *Nothofagus*, rotting logs and over bryophytes in Chile, and on the bark of *Metrosideros* and over bryophytes in the Auckland Islands.

Material Examined

Specimens seen.--ARGENTINA. I. Estados: B. Crossley, Imshaug 50651, 50724 (MSC), P. Roca, Imshaug 51206A (MSC), P. Basal

Hall, Imshaug 51343 (MSC), P. Abrigato, Imshaug 51367 (MSC), B. Primera, Imshaug 52368, 52425, 52432 (MSC), P. Parry, Imshaug 54023 (MSC). - CHILE. Prov. Chiloe: P. Ballena, I. Mulchey, Imshaug 43191 (MSC); Prov. Magallanes: I. Juan, B. Wide, Imshaug 44235 (MSC), P. del Morro, Imshaug 43752B (MSC).

AUCKLAND ISLAND. between head of Musgrave Inlet and Lake Hinemoa, Imshaug 56461 (MSC); W arm of Musgrave Harbour, Imshaug 57080 (MSC); Adams I., Imshaug 57456 (MSC); North Harbour, Imshaug 57749, 57792 (MSC); Cove to E of Tagua Bay and W of Mt. D'Urville, Imshaug 57392, 57415 (MSC).

16. Sphaerophorus insignis Laur.

Linnaea 2: 45. 1827. Sphaerophoron australe f. insigne (Laur.) Müll. Arg. Flora 66: 17. 1883. Sphaerophorus melanocarpus var. australis f. insignis (Laur.) Murr. Trans. Roy. Soc. New Zealand 88: 190. 1960. Type: Australia, Sieber s.n. (BM, lectotype).

Sphaerophoron ceranoides Hampe, Linnaea 28: 217. 1856. Type: Australia, Sealers Cove, Aug. 1854 Hampe (MEL, holotype).

Nomenclatural Remarks

Material of Sphaerophorus insignis Laur. from the British Museum and collected by Sieber in Australia has been selected as the lectotype (see Figure 7). The label for the specimen seems to be written in Siebers own handwriting and it is also noted as an "authentic specimen." Although the specimen is only a sterile fragment, it can be seen to have a dark brownish upper surface and a flattened branch morphology which is very characteristic. Thin-layer chromatography indicated the presence of sphaerophorin and protocetraric acid.

Holotype material of _S. ceranoides_ Hampe has been examined (see Figure 8) and is placed in synonomy with _S. insignis_.

Description

Thallus corticolous, subimbricate, usually producing several horizontal somewhat overlapping branches. Primary branches fertile, flattened, with a distinct upper and lower surface, to 5 cm in length, 2-6 mm in width, with numerous short, flattened, sterile branchlets crowded at the base. Short secondary branchlets produced irregularly along the margins. Upper surface dark brown to dark green, smooth, convex, transversely annulate-cracked, with small isidioid structures produced along the cracks, especially over the apothecium; lower surface light brown to white, irregularly wrinkled to lacunose. Cortex composed of thick-walled, gelatinized and fused hyphae intricated in various directions; upper cortex of primary branches, brownish, dense, 90-130 μ thick, lower cortex 50-90 μ thick, colorless. Algal-medullary layer 25-45 μ thick, continuous beneath the upper cortex, rarely occurring on the lower side; algae protococcoid, spherical, 7-10 μ in diameter. Medulla composed of thick-walled, colorless, longitudinally arranged hyphae, 5-7 μ in diameter, generally distinct from each other and loosely intricated. Apothecia 2-8 mm across, subterminal, typically broader than the supporting fertile branch; with numerous small branchlets or outgrowths forming along the lower margin. Mazaedium ventrally oriented, covered, finally becoming exposed through a small opening in the enclosing receptacle; the receptacle always persistent and at least partically covering the mazaedium. Asci cylindric, near maturity 50-65 X 5-7 μ, containing 8 spores arranged in a row. Spores spherical, brown, (10)-12-15 -(16) μ in diameter; commonly surrounded by a dark carbonaceous material. Pycnidia occasional in terminal areas.

Medullary reactions.--PD + red, KOH -, KC -, C -, I -.

Constituents.--Sphaerophorin and protocetraric acid. In nearly 8% of the 175 specimens studied, sphaerophorin could not be detected. Protocetraric acid was found in all specimens.

Discussion

The broad apothecia with its surface consistently covered by the enclosing receptacle when mature, is the most characteristic feature of this species (see Figure 8). All other species within the subgenus have apothecia that have well-exposed mazaedia. The dark brown to green upper surface, the broadened nature of the primary branches, and the isidioid bodies along the apothecial margin are also major characteristics of *S. insignis*.

Sphaerophorus insignis is a widely distributed southern hemisphere species (see Figure 60), growing usually over bark in protected semi-shady, moist habitats.

Material Examined

Chemotype I (Sphaerophorin and protocetraric acid)

Exsiccati seen.--Malme Austro. 452 (H, MSC, BM, US).

Specimens seen.--NEW ZEALAND. locality unknown, coll. unknown (BM), Bower s.n. (MICH), Knight s.n. (BM), 1867 Knight 105 (H-Nyl. 40357), 1867 Knight 105a (H-Nyl. 40344), 1869? Knight (H), 1841 Hooker (FH-Tayl. 156); NORTH I. locality unknown, Colenso s.n. (BM), Colenso 5189 (BM); Fagus wood, Colenso 1697 (WELT); Mt. Tararua, Buchanan s.n. (BM); Lake Rotorua, Scott 366 (OTA); Hawera, Colenso 2713 (WELT); Kotukutuku, Colenso 5094 (WELT, BM). SOUTH I. Nelson: Nelson mountains, Sinclair s.n. (BM), Cobb River Dam, Mason 625, 616, 615 (OTA), Lake Rotoiti, Whiskey Falls, Taylor L-36150 (CAN), W side of Lewis Pass, Imshaug 55720, 55708B (MSC); Canterbury: Lewis Saddle, 1958 Martin (OTA), Mt. Pleasant, 1880 Reader (MEL), 6.5 mi. E of Hanmer Springs Junct., Imshaug 55916B (MSC); Westland: Greymouth, 1956 Martin (OTA), Lake Wahapo, Imshaug 48062 (MSC), Gillespies Cook River Road, between Tornado Creek and Whelan Creek, Imshaug 47962 (MSC), near Runanga, 1958 Martin (OTA); Malvern: Bealey Glacier Vista, Imshaug 48145, 48153, 48162, 48177 (MSC), Avalanche Peak Track, Harris 6558-B (MSC); Otago: Matukituki Valley, 1961 Campbell (OTA), 1959 Scott (OTA), Matukituki River, 1959 Thompson (OTA), Leith Valley Saddle, Dunedin, Murray 3548 (OTA); Southland: Main Divide, Hollyford-Eglinton Valleys, Imshaug 58051 (MSC), Lake Howden, Murray 0815 (OTA). - AUCKLAND ISLAND. Adams I., Imshaug 57174 (MSC); between head of

Smith Harbour and Norman Inlet, Imshaug 57277(2) (MSC); S side of Granges Inlet, Imshaug 57640 (MSC). - CAMPBELL ISLAND. locality unknown, 1874 Filhol (PC), Perseverance Harbour, Imshaug 47177 (MSC); between Garden and Venus Coves, Imshaug 47108 (MSC); SW of Sorenson Hut, Imshaug 47240 (MSC). - TASMANIA. locality unknown, coll. unknown (US, BM), Lindley s.n. (FH-Tuck, 3747), 1840 Hooker (FH-Tayl. 156); near Adamsfield, Bratt 68/150 (MSC); Ball Room Forest, S of Burnie, Bratt 67/607b (MSC); Myrth Gully, Bratt 296 (BM); Mt. Wellington, Weymouth s.n. (MICH); Mt. Barrow, between Launceston and Scotsdale, 1965 Allender (MEL). - AUSTRALIA. locality unknown, Sieber s.n. (BM), Muller s.n. (FH-Tuck. 3747), 1841 Dr. Greville (FH-Tuck, 3747); VICTORIA: Sealers Cove, 1854 Hampe (MEL), Warburton, Wilson 14 (FH), Healesville, Bastow s.n. (MICH), Mt. Ellery, Merratt s.n. (FH-Tayl. 144, FH, MEL, BM), Möe, Gippsland, Webb s.n. (H, FH); NEW SOUTH WALES: Barrington Tops, Cobby's Bluff, Filson 5651 (MEL), Gloucester Tops, W of Darby, Filson 11627 (MEL), Gloucester River, Gloucester Tops, Filson 5583 (MEL), 2 mi., SW of Darby Munro Hut, Filson 11600 (MEL).

ARGENTINA. I. Grande: B. Buen Suceso, Imshaug 50249, 50077, 50090, 50075, 49972 (MSC). B. York, Lechler 1332 (PC, PC-Hue, FH, BM, H-Nyl. 40343); I. Estados: P. Hoppner, Imshaug 53671 (MSC), P. Parry, Imshaug 53976 (MSC), B. Flinders, Imshaug 53466 (MSC), P. Basil Hall, Imshaug 51341, 51320 (MSC), P. Cook, Imshaug 51480 (MSC), P. Celular, Imshaug 52732, 52686, 52653, 52517 (MSC), B. Crossley, Imshaug 50796, 50767, 50646 (MSC), I. Observatorio, Imshaug 50967 (MSC); Prov. Rio Negro: Lago Nahuel Huapi, Lago Frias, Kalela 101e (H); Prov. Neuquen: Lago Correntoso Kalela 26e, 28e (H); Prov. Chubut: Lago Menéndez, Kalela 246e (H), Rio Navarro, 1941 Kühnemann (CAN). - CHILE. locality unknown, coll. unknown (H-Nyl. 40348), Gay s.n. (BM, FH-Tuck. 3747), coast of Patagonia, Lobb (BM); Prov. Magallanes: I. Clarence, 1929 Roivainen (H), Hariot 15 (PC-Hue), I. Williams, B. Tribune, Canal Messier, Imshaug 43429, 42410 (MSC), I. Wellington, P. Charrua, Imshaug 43787 (MSC), I. Chatham, B. Wide, Imshaug 44312 (MSC), B. Fortescue, Imshaug 44966 (MSC), I. Hermite, 1842 Hooker (FH-Tayl. 157). P. Arturo, 1929 Roivainen (H), Cape Horn, 1842 Hooker (BM), B. San Nicolas, Imshaug 45574 (MSC), P. Famine [P. del Hambre], King s.n. (BM), Seno Otway, B. Camden, Imshaug 39077 (MSC), P. Cutter, Imshaug 39356 (MSC); Prov. Aisen: P. Otway [P. Barroso], Cunningham s.n. (BM); Prov. Chiloe: Huite, 1868 Cunningham (BM); Prov. Valdivia: locality unknown, Lechler 355 (PC, BM); Cerros Los Tayos, 1929 Hollermayer (H); Quitaluto [Corral], Hosseus 50 (H); Arique [Cordillera de Ranca], Lechler 637 (PC); Prov. Osorno: Refugio Antillanca, Imshaug 42865 (MSC); Prov. Bio-Bio: Antuco, 1828 Bertero (FH); Prov. Llanquihue: Volcan Calbuco, Barros 134 (H).

Chemotype II (Protocetraric
acid only)

Specimens examined.--NEW ZEALAND. locality unknown, coll. unknown (BM), Cunningham 68 (BM); NORTH I. Mauriceville [Masterton], Gray 12L (US); Little Barrier I. [Hauturu I.], 1959 Chapman (OTA). SOUTH I. Nelson: locality unknown, Mueller s.n. (H-Nyl. 40358), Buller Gorge, W of Inangahua Junct., Imshaug 55810 (MSC); Southland:

E side of Wilmot Pass, Murray 3931 (OTA). - CAMPBELL ISLAND. locality unknown, 1874 Filhol (H-Nyl. 40345). - AUSTRALIA. VICTORIA: locality unknown, Mueller 136 (BM), Sealers Cove, 1854 Hampe (MEL). - ARGENTINA. Prov. Chubut: Rio Navarro, 1941 Kühnemann (CAN). - CHILE. locality unknown, Gay s.n. (H-Nyl. 566); Prov. Magallanes I. Pilot, P. del Morro, Imshaug 43752B (MSC); Prov. Osorno: Refugio Antillanca, Imshaug 42901 (MSC).

17. Sphaerophorus macrocarpus Ohlsson, spec. nov.

Apothecia magna, 4.6.5 mm lata. Sporae brunneae, globosae, 8.0-10.0 µ diam. Solum sphaerophorin vel aliqaudo sphaerophorin acidum sticticum and acidum consticticum contineus.

Type: New Zealand, South Island, Westland, Gillespies Cook River Road, between Tornado Creek and Whelan Creek, Harris 6241 (MSC, holotype).

Description

Thallus corticolous, erect, well-developed, producing numerous crowded branches. Primary branches near the base rather narrow becoming broadly flattened 3-6 (11) mm wide and irregularly subflabellate; several narrowly compressed branches produced along the upper margin. Fertile branches narrow (to 2 mm in width) extending above the sterile branches, to 6 cm in length, and when mature producing broadly flaring apothecia. Upper surface full, grayish green, smooth, transversely annulate-cracked in larger more mature branches, becoming wrinkled to rugose on the upper part of the apothecium; lower surface light colored, smooth or irregularly wrinkled. Cortex composed of thick-walled, gelatinized and fused hyphae intricated in various directions; upper cortex of mature branches 80-100 μ thick, lower cortex 40-80 μ thick. Algal-medullary layer 10-20 μ thick, continuous beneath the upper cortex, rarely occurring on the lower side; algae protococcoid, spherical, 7-10 μ in diameter. Medulla composed of thick-walled, colorless, longitudinally arranged hyphae 5-9 μ in diameter, generally distinct and loosely intricated. Apothecia broadly flaring, when mature 4.6.5 mm across, located ventrally on the relatively thin (2 mm) fertile branches. Mazaedium well-exposed, black, loose and globose. Asci cylindric, near maturity 40-60 X 5-7 μ, containing 8 spores arranged in a row. Spores spherical, brownish gray, 8.0-10.0 (12.0) μ in diameter, commonly surrounded by a black carbonaceous material. Pycnidia common in apical areas.

Medullary reactions.--PD -, KOH -, KC -, C -, I -.

Constituents.--Sphaerophorin was found in all specimens and in five of seventeen specimens it occurred with stictic and constictic acids.

Discussion

The large globose to subglobose flaring apothecia are very characteristic, as are the broadly flattened subflabellate sterile branches (see Figure 17). The average spore size (8-10 μ) and the chemistry are also useful in the identification of this species. In sterile atypical material growing in extremely exposed environmental conditions such as rock outcrops, this species could possibly be confused with S. patagonicus, with both having sphaerophorin as the only lichen product.

Sphaerophorus macrocarpus is known from New Zealand, Campbell Island, the Auckland Islands, and Tasmania (see Figure 61). Most collections are corticolous, but occasionally they occur over rock and bryophytes.

Material Examined

Chemotype I (Sphaerophorin)

Specimens seen.--NEW ZEALAND. SOUTH I. Nelson: 8 mi. E of Reefton, Imshaug 55844 (MSC); Westland: Gillespies Cook River Road, between Tornado Creek and Whelan Creek, Harris 6226, 6241 (MSC); Malvern: Bealey Glacier Vista, Harris 6374 (MSC), Punchbowl Creek Trail, Imshaug 48211 (MSC); Otago: Matukituki Valley, 1959 Scott (OTA); Southland: Lake Hauroko, 1958 Hunter (OTA). - AUCKLAND ISLAND. ridge, SE of Mt. Raynal, Imshaug 57322 (MSC). - CAMPBELL ISLAND. Mt. Lyall, Imshaug 46470 (MSC). - TASMANIA. Ball Room Forest, 42 mi. S of Burnie, Bratt 67/607 (MSC); Track from Dove Lake Turntable to Hanson's Peak, Filson 10733 (MEL); W of Waldheim, Filson 10382a (MEL).

Chemotype II (Sphaerophorin, stictic acid, and consticitic acid)

Specimens seen.--AUCKLAND ISLAND. Adams I., Imshaug 57093 (MSC); N side of Musgrave Inlet, Imshaug 56517 (MSC); Cloudy Peak, Imshaug 57541 (MSC). - TASMANIA. Dove Lake near Waldheim, 1965 Allender (MEL); Pine Valley Hut, Lake St. Clair Nat'l. Park, Filson 6900a (MEL).

18. *Sphaerophorus murrayii* Ohlsson, spec. nov.

Similis *Sphaerophorus patigonico* (Dodge) Ohls. sed differt ramis principalibus elongatioribus et leuiter decumbentibus, 2-5 cm longis; sporis 10.0-12.5 μ diam.; sphaerophorin et acidum protocetraricum continente.

Type: New Zealand, South Island, Westland, 8 mi. W of Turiwhate, Harris 6343 (MSC, holotype).

Sphaerophorus australis f. *subteres* Zahlbr. in Magn. Ark. Bot. 31A(1): 24. 1943. *Sphaerophorus melanocarpus* var. *australis* f. *subteres* (Zahlbr. in Magn.) Murr. Trans. Roy. Soc. New Zealand 88: 191. 1960. Type: Hawaii, Kauai I., Rock 8 (FH, cotype).

Nomenclatural Remarks

Although the material collected by Rock could have been selected as the type material for this species, it was believed that more typical and fertile material should be chosen. For this reason a collection from New Zealand, where *S. murrayii* seems to be most typical, was selected. A photograph of the holotype material is included in Figure 16.

Description

Thallus corticolous, elongate, producing numerous crowded, weakly decumbent or horizontal subimbricate to intricate primary branches. Primary branches flattened with a distinct upper and lower surface, to 5 cm in length, 1.0-2.5 mm in width, margins typically irregular producing small branchlets or outgrowths, less often margins plain. Branching irregular or anisotomic dichotomous. Upper surface greenish-gray, convex, smooth basally producing irregular outgrowths over the mazaedium, occasionally transversely annulate-cracked; lower surface light colored, irregularly wrinkled to lacunose. Cortex composed of thick-walled, gelatinized and fused hyphae intricated in various directions: upper cortex of primary branches 40-70 μ thick, lower cortex 20-40 μ thick. Algal-medullary layer 15-25 μ thick, continuous beneath the upper cortex, but occurring rarely as isolated groups above the lower cortex; algae protococcoid, spherical, 8-10 μ in diameter. Medulla composed of thick-walled, colorless, longitudinally arranged hyphae 5.5-8.0 μ in diameter, generally loosely intricated and distinct from each other. Apothecia common, typically irregular in outline, producing minute outgrowths or small branchlets along its lower side, 0.4-2.0 mm across, located subterminally on the primary branches. Mazaedium oriented ventrally, becoming exposed at an early stage of development by the irregular rupturing of the enclosing receptacle along its lower surface; when mature, prominent, black, and globose. Asci cylindric, near maturity 45-65 X 5-7 μ, containing 8 spores arranged in a row. Spores spherical, brown, (9-) 10.0-12.5 (-14) μ in diameter, commonly surrounded by a black carbonaceous material. Pycnidia common in terminal areas.

Medullary reactions.--PD + red, KOH -, KC -, C -, I -.

Constituents.--Sphaerophorin and protocentraric acid. In almost a third of the 29 specimens, sphaerophorin could not be demonstrated. This is thought to be of little significance as it could not be correlated with any morphological, substrate or distributional differences.

Discussion

Sphaerophorus murrayii superficially is quite similar in thallus morphology to *S. patagonicus*, but it generally has more elongate and weakly decumbent branches and produces irregular outgrowths along the margins and apothecium. The mazaedium is also characterized as spherical or almost "ball-shaped" and free from the surrounding receptacle (see Figure 16). Another distinctive difference is the presence of protocetraric acid in *S. murrayii*.

This species has been found in New Zealand, Sumatra, and Hawaii (see Figure 62). According to label data, most collections have come from forested areas at fairly high elevation.

Material Examined

Chemotype I (Sphaerophorin and protocetraric acid)

Specimens seen.--HAWAII. KAUAI I., Rock 8 (FH). - PHILIPPINES. LUZON. Prov. Benguet: Mt. Tonglon, Merrill 4895

(US), Mt. Data, Hale 26334 (US); Prov. Rizal: 1911 Ramos (US), 1916 Ramos (H). MINDANAO. vicinity of Tanculan, 1916 Fenax (FH). - NEW GUINEA. Mt. Suckling, 1891 Mac Gregor (H). - SABAH. near Kundason, Sosopodon Shelter, Hale 29134 (US); between Layang Layang and Paka Cave, Hale 28650 (US). - SUMATRA. Mt. Singalang, 1894 Schiffner (FH). -

NEW ZEALAND. NORTH I. Dannevirke, Colenso 1612 (WELT). SOUTH I. Nelson: Rainy River, Wells & Hollyman s.n. (OTA), Buller Gorge, Imshaug 55802 (MSC); Westland: 8 mi. W of Thuriwhate, Harris 6332(MSC), Imshaug 48100 (MSC); Southland: Secretary I., Murray 3994 (OTA).

Chemotype II (Protocetraric acid)

Specimens examined.--NEW ZEALAND. NORTH I. Hawkes Bay, 1899 Beckett (BM). SOUTH I. Westland: 8 mi. W of Thuriwhate, Harris 6363B, 6343 (MSC), Imshaug 48085, 48106, 48113 (MSC), terminal moraine of Fox Glacier, Imshaug 47990 (MSC); Southland: Fiordland Nat'l. Park, Taylor L-36131 (FH), E of Milford Sound, Imshaug 57921 (MSC). - AUCKLAND ISLAND. locality unknown, 1853 Jolliffe (BM). - TASMANIA. Purgatory Gap, 17 mi. S of Queenstown, Bratt 71/962 (MSC).

19. Sphaerophorus patagonicus (Dodge)
Ohlsson, comb. nov.

Pleurocybe patagonica Dodge, Nova Hedwigia 16: 484, 1969. Type: Argentina, Parque Nacional Nahuel Huapi, Rio Negro, Rucumalen, on trail to Lagunilla Espejo Chico, C. W. & B. S. Dodge 700 (DODGE, holotype, p. p.).

Nomenclatural Remarks

Dodge reported the spores from *Pleurocybe patagonica* as "hyaline unilocular, spherical, 6 μ in diameter" which actually describes the spores from the Thaxter material that is cited in his paper. Spores studied from the type material of *P. patagonica* are spherical, but much larger, 12-15 μ in diameter and are brown in color. The material collected by Thaxter from Corral, Chile is described as a new species in this paper and is called *Sphaerophorus dodgei* in honor of the American lichenologist Carroll W. Dodge.

Although Dodge placed *S. patagonicus* in *Pleurocybe*, which I have also included in the genus *Sphaerophorus*, his species is quite distinct from *Pleurocybe* and should be placed in a separate group, i.e., subgenus *Aghimus*. *Sphaerophorus madagascareus* (= *Pleurocybe madagascareus*) belongs to subgenus *Bunodophorus*.

Description

Thallus corticolous, subimbricate with several horizontal or decumbent primary branches forming near or on top of each other. Primary branches fertile, distinctly flattened, irregularly branched, to 5 cm in length, 2-5 (8) mm in width. Sterile basal branches shorter, flattened, sparsely branched. Upper surface brown to grayish-green, usually smooth becoming rugose and transversely annulate-cracked; in older, larger branches, the upper surface is convex, due to the thickened margins which are normally rolled under and plain near the apothecium; lower surface concave to nearly flat, light colored, smooth to irregularly wrinkled to lacunose near the apothecium. Cortex composed of thick-walled, gelatinized and fused hyphae, intricated in various directions and covered by a thin (1-3 μ) colorless epicortex; upper cortex of primary branches 60-100 μ thick, lower cortex thinner, 20-40 μ thick. Algal-medullary layer 20-40 μ thick, continuous beneath the upper cortex, rarely occurring on the lower side; algae protococcoid, spherical, 7-10 μ in diameter. Medulla composed of thick-walled, colorless, longitudinally arranged hyphae, 5-8 μ in diameter, generally distinct and loosely intricated. Apothecia common, sinuses rounded, without any branchlets, 1-5-4.0 (7.0) mm across, located at the subterminal ends of the primary branches. Mazaedium ventrally oriented, exposed at an early stage of development by the irregular rupturing of the enclosing receptacle; when mature, exposed but the sides remaining partially enclosed by the receptacle, black or more typically covered by a fine grayish dust. Asci cylindric, near maturity, 50-65 X 5-8 μ, containing 8 spores arranged in a row. Spores spherical, brown, (10-) 12-15 (-16) μ in diameter. Pycnidia common in terminal areas.

<u>Medullary reactions</u>.--PD -, KOH -, KC -, C -, I -.

<u>Constituents</u>.--Sphaerophorin was found to be present in all 63 specimens tested. In eight of thirteen specimens from southern South America an unknown substance was also found to occur

usually in trace amounts. This substance did not react with PD nor H_2SO_4, but did fluoresce somewhat under UV light.

Discussion

Sphaerophorus patagonicus is somewhat similar in appearance to S. murrayii, in terms of general apothecial morphology and spore characters (see Figure 17). Major differences include a more sunken or protected mazedium, the unbranched and thickened margins which tend to foll under, and the complete lack of protocetraric acid in the former species. Sphaerophorus patagonicus is restricted to wood or bark, occurring in moist, shady habitats. It has an oceanic southern hemisphere distribution with specimens examined from Chile, Argentina, New Zealand, Campbell Island, and Tasmania (see Figure 63).

Material Examined

Specimens seen.--ARGENTINA. Prov. Chubut: Lago Menendez, Kalela 242C (H), Lamb 5924 (CAN, H, FH); Prov. Rio Negro: Lago Nahuel Huapi, Kalela 111S, 106 (H), Lago Frias, Lamb 5989 (CAN), trail to Lagunella Espejo Chico, C. W. Dodge & B. S. Dodge 700 (DODGE); Prov. Neuquen: Brazo Blest, 1938 Kull (CAN), coll. unknown 39 (H); Tierra del Fuego: B. Buen Suceso, Imshaug 50084, 50197, 50251 (MSC), B. Valentin, Imshaug 50524 (MSC); Isla de los Estados: B. Crossley, Imshaug 50836 (MSC), P. Roca, Imshaug 51206B (MSC), P. San Juan, Imshaug 51819 (MSC), B. Primera, Imshaug 52387 (MSC), P. Celular, Imshaug 52629 (MSC), B. Flinders, Imshaug 53372, 53388, 53393, 53448 (MSC). - CHILE. Prov. Magallanes: between B.

Bougainville and B. San Nicolas, Imshaug 45499 (MSC), B. San Nicolas, Imshaug 45622 (MSC), B. Camden, Seno Otway, Imshaug 39077B (MSC), I. Clarence, Bahia Pond, Imshaug 45288 (MSC), P. Gallant, Imshaug 45039 (MSC), Caleta Amalia, Imshaug 44448, 44441 (MSC), I. Chatham, E of Bahia Wide, Imshaug 44303 (MSC), I. Mornington, P. Alert, Imshaug 43924B (MSC), I. Williams, Bahia Tribune, Imshaug 43406 (MSC); Prov. Chiloe: I. Mulchey, P. Ballena, Imshaug 43185 (MSC); Prov. Osorno: Refugio Antillanca, Imshaug 42861, 42863, 42864, 42943 (MSC).

NEW ZEALAND. locality unknown, Mitten s.n. (MICH). NORTH I. locality unknown, Colenso s.n. (BM); Ball's Clearing, 25 Dec. 1958 coll. unknown (OTA). Aniwaniwa Falls, 1966 Wade (BM); Mt. Tararua, Buchanan s.n. (BM); Manawatu, Colenso 2714 (WELT). SOUTH I. Nelson: Lewis Pass, 12 mi. E of Springs Junct., Imshaug 55735 (MSC); Westland: Greymouth, Helms s.n. (H), 8 mi. W of Turiwhate, Harris 6358 (MSC), Imshaug 48107 (MSC), Gillespies Cook River Road, between Tornado Creek and Whelan Creek, Imshaug 47965 (MSC); Westland and Otago boundary, Haast Pass, 1957 Smiths (OTA); Otago: Matukituki Valley, 1959 Crimp (OTA); Southland: The Chasm, Claddau River, Imshaug 57968, 57965 (MSC). STEWART I. Port Pegasus, Imshaug 57816 (MSC). - CAMPBELL ISLAND. Mt. Lyall pyramid, Imshaug 46455 (MSC); Mt. Honey, Harris 4946 (MSC). - TASMANIA. locality unknown, Gunn s.n. (BM); Serpentine Road, W of Maydena, Bratt 68/228 (MSC); Florentine Valley, NW of Maydena, Bratt 68/307a (MSC); Purgatory Gap, S of Queenstown, Bratt 71/1003 (MSC); Table Mt. Brown s.n. (BM). - AUSTRALIA. NEW SOUTH WALES. Darby Munro

Hut, Gloucester Tops, _Filson 5621_ (MEL). VICTORIA. Mait Rest Scenic Reserve, Parker River, 1969 _Allender_ (MEL); Blue Range, Whitehorse, _Filson 6503_ (MEL). - _NEW GUINEA_. locality unknown, 1896 _Guilianetti_ (BM).

20. _Sphaerophorus scrobiculatus_ (Bab. _in_ Hook, f.) Sato

Misc. Bryol. Lichenol. 4: 151. 1968. _Sphaerophoron australe_ var. _scrobiculatum_ Bab. in Hook, f. Bot. Ant. Voy. 2(2): 304, _pl_. _130_ _C_. _f_. _3_. 1855. _Sphaerophorus melanocarpus_ var. _scrobiculatus_ (Bab. in Hook, f.) Murr. Trans. Roy. Soc. New Zealand 88: 192. 1960. Type: New Zealand, Northern and Middle Islands, _Colenso_ s.n. (BM, lectotype).

Nomenclatural Remarks

Specimens and illustrations matching Plate 130-C in Hooker (1855) have been studied from the British Museum. The material consists of three specimens which I have designated as specimens 3 and 4 (see Figure 20), conforming to the numbering in Hooker. The two specimens in Figure 20-3 are selected as lectotype material. Specimen 4 was found to be _S_. _insignis_.

Description

Thallus corticolous or occurring over rock; well developed, consisting of 1 to several primary branches, at first broadly flattened, then dividing in a palmate fashion into several smaller usually fertile branches. Primary branches horizontal, to 3 cm in length, 4-11 mm in width, commonly with small, irregular, secondary branches forming marginally. Upper surface greenish gray, smooth to rugose becoming scrobiculate in the terminal areas, especially over the apothecia; lower surface white, irregularly wrinkled, especially around the base of the apothecium. Cortex composed of thick-walled, gelatinized and fused hyphae intricated in various directions; upper cortex of primary branches 65-100 μ thick, lower cortex 40-70 μ thick. Algal-medullary layer 20-40 μ thick, continuous beneath the upper cortex only; algae protococcoid, spherical, 8-10 μ in diameter. Medulla composed of thick-walled, colorless, longitudinally arranged hyphae, 5-8 μ in diameter, generally distinct from each other and loosely intricated. Apothecia common, 2-9 mm across, typically broadly flairing, located on the subterminal ends of the primary branches. Mazaedium ventrally oriented, exposed at an early stage of development by the irregular rupturing of the enclosing receptacle on its lower side. Receptacle corticate with small isidioid structures found along the margin. Asci cylindric, near maturity 45-55 X 5-7 μ, containing 8 spores arranged in a row. Spores spherical grayish-brown 9-12 (-13.5) μ in diameter, commonly surrounded by a black carbonaceous material. Pycnidia rare in terminal areas.

Medullary reactions.--PD -, KOH + trace reddish, KC - reddish, C -, I -.

Constituents.--The substances found in this species consist of three unknowns including a possible anthraquinone and a compound of relatively high concentration which turns red when spotted with KOH or KC. The third unknown is present in various concentrations and is often not detected by thin-layer chromatography. For further characterization, see page and Table 3. This is the only species in which no sphaerophorin has been found. Although some would create a new genus based on this major chemical difference, I believe the important morphological characteristics are all consistent with the genus concept of *Sphaerophorus* and the unknown substance may be found to be closely related to other lichen compounds in the genus.

Discussion

Other than the unique chemistry, the main diagnostic characteristics of this species include the broad and flattened nature of the thallus and the scrobiculate surface of the receptacle. A specimen of somewhat different morphology from Juan Fernandez has slightly smaller branches and almost globose apothecia instead of the more typical broadly flaring apothecia. The spores are also slightly smaller but the unique unknown substance is present and this specimens may be an extreme of a somewhat variable species.

Sphaerophorus scrobiculatus is strictly a southern hemisphere species, occurring over rock in Campbell Island and occurring equally on rock and on trees or wood in New Zealand, Tasmania and Chile (see Figure 64 for the distribution of this species).

Material Examined

Specimens seen.--NEW ZEALAND. locality unknown, Oldfield s.n. (FH). NORTH I. locality unknown, Colenso s.n. (BM); SOUTH I. locality unknown, Lyall s.n. (BM); Nelson: Anatoki, 1863 Haast (BM), Spey River, Murray 3918 (OTA), 0.4 mi. W of Rahu Saddle, Imshaug 55850 (MSC); Westland: locality unknown, coll. unknown (BM), Lake Whapo, Harris 6313 (MSC), Gillespies Cook River Road, between Tornado Creek and Whelan Creek, Imshaug 47954 (MSC), Greenland hill, Bloxam s.n. (BM), Greymouth, Helms s.n. (H); Styx River, Scott 135 (OTA); Malvern: Punchbowl Creek Trail, Imshaug 48201 (MSC), Avalanche Peak Track, Harris 6463A, 6461 (MSC); Canterbury: locality unknown, 1860-61 Sinclair & Haast (BM); Southland: Secretary I., Murray 4051, 3991, 3990, 3979, 3993 (OTA). STEWART I., Port Pegasus, Imshaug 57826, 57844 (MSC). - AUCKLAND ISLAND. near head of Musgrave Inlet, Imshaug 56562, 56542, 56574 (MSC); between head of Musgrave Inlet and Lake Hinemoa, Imshaug 56467 (MSC); Mt. Eden, Imshaug 57496 (MSC); ridge, E of Mt. Raynal, Imshaug 57336, 57344 (MSC); ridge, SE of Mt. Easton, Imshaug 56508 (MSC); NW end of North Arm, Carnley Harbour, Imshaug 57014 (MSC); ridge between head of Smith Harbour and Norman Inlet, Imshaug 57231(2), 57249(2) (MSC); Cloudy Peak, Imshaug 57550 (MSC); head of Tandy Inlet, Imshaug 57590 (MSC); Granger Inlet, Imshaug 57627 (MSC): SW side of South Arn, Hanfield Inlet, Imshaug 57748 (MSC). - CAMPBELL ISLAND. Mr. Lyall pyramid, Imshaug 46490, 46496B (MSC); W end of Lyall ridge, Harris 5657, 4392 (MSC); Mt. Lyall, Imshaug

47424 (MSC); Mt. Faye, Imshaug 47343 (MSC); Mt. Sorenson, Imshaug 47332, 47318, 47308 (MSC); Mt. Honey, Imshaug 46370 (MSC). - TASMANIA. Hartz Lake, Bratt 723 (BM); near Waldheim, S of Burnie, Bratt 70/535 (MSC); 15 mi. S of Waratah, Bratt 2406 (MSC).

CHILE. Prov. Aisen: P. Island, Peninsula Swett, Imshaug 43234 (MSC), Fiordo Tempano, Imshaug 43329 (MSC); Prov. Magallanes: P. del Morro, I. Pilot, Imshaug 43714 (MSC), I. Mornington, P. Alert, Imshaug 43846 (MSC), I. Juan, Bahia Wide, Imshaug 44252 (MSC), I. Chatham, E of Bahia Wide, Imshaug 44336 (MSC), P. Bueno, Imshaug 44530, 44575 (MSC), I. Desolacion, Bahia Tuesday, Imshaug 44685 (MSC). - JUAN FERNANDEZ. MAS A TIERRA. NE wall of El Yunque, Imshaug 37764 (MSC).

TABLE 7. Summary of chemotypes and lichen substances found in Sphaerophorus. The substances found in the type specimen for each species is indicated by an (*) and is placed in Chemotype I (see Lamb, 1951). # indicates the number of specimens surveyed by thin-layer chromatography.

Species	Chemotype	Substances	% of Specimens
coomerensis (4)#	I*	Sphaer.	100
diplotypus (37)	I*	Sphaer., stict., & constict.	18
	II	Sphaer.	82
dodgei (24)	I*	Sphaer. & "Dodgei" unknown	75
	II	Sphaer.	25
formosanus (154)	I*	Sphaer.	16
	II	Sphaer., stict., & constict.	79
	III	Sphaer. & stict.	5
fragilis (240)	I*	Sphaer. & hypo.	20
	II	Sphaer.	5
	III	Sphaer. & squamat.	60
	IV	Sphaer., squamat., & hypo.	15
globosus (1243)	I	Sphaer.	30
	II	Sphaer. & thamnol.	45
	III	Sphaer. & squamat.	17
	IV	Sphaer. & hypo.	2
	V	Sphaer., squamat., & hypo.	4
	VI	Sphaer., squamat., & thamnol.	2
imshaugii (19)	I*	Sphaer. & protocet.	100
insignis	I*	Sphaer. & protocet.	92
	II	Protocet.	8
kinabaluensis (21)	I*	Sphaer., stict., & constict.	100

TABLE 7.--Continued.

Species	Chemotype	Substances	% of Specimens
macrocarpus (17)	I*	Sphaer.	71
	II	Sphaer., stict., & constict.	29
madagascareus (100)	I*	Sphaer., stict., & constict.	100
meiophorus (60)	I*	Sphaer. & squamat.	100
melanocarpus (423)	I*	Sphaer., stict., & constict.	88
	II	Sphaer.	12
microsporus (7)	I*	Sphaer. & protocet.	100
murrayii (29)	I*	Sphaer. & protocet.	71
	II	Protocet.	29
patagonicus (63)	I*	Sphaer.	100
ramulifer (261)	I*	Sphaer. & isousnic	53
	II	Sphaer., stict., constict., & isousnic	17
	III	Sphaer., constict., & isousnic	14
	IV	Sphaer., "Coccotrema" unknown, & isousnic	16
scrobiculatus (66)	I*	"Scrobiculatus" unknown	100
stereocauloides (37)	I*	Sphaer.	100
tener (487)	I*	Sphaer.	100

NOMINA INQUIRENDA

The following names have not been typified as the specimens were unavailable for study.

Coralloides alpinum Dill. Hist. Musc., London 3, 2. 1763. Original material: Mt. Snowdon, and mountains in Wales.

According to Crombie (1880) this collection consists of three specimens of which A and B are *S. fragilis* and C is *S. compressum* Ach.

Sphaerophoron australis f. *angustior* Reinke, Jahrb. Wis. Bot. 28: 85. 1895. Original material: Australia, "from the Kieler Herbarium."

Lichen caespitosus Roth. Tentam. Flor. German. 1: 513. 1788. Original material: "Habitat in saxis montosis Bructeri et alibi in taxon cannot even be tentatively placed in synonomy.

Sphaerophoron coralloides b. *candicans* Fr. Lich. Europ. 405. 1831. Original material: "per Europam fere omnem; sed, ex Schaerero, in Helvetia desideratur."

This taxon will probably be placed in synonomy with *S. globosus* with which "coralloides" is commonly associated.

Sphaerophoron compressum var. *candidum* Müll. Arg. Flora 14: 505. 1881. Original material: Australia, North Queensland, in Bellender Ker Range, Karsten.

Sphaerophoron fragile f. ceylonica Kremp. Verh. K.K. Zool.-Bot. Ges. Wien 26: 446. 1876. Original material: Ceylon, Pedrotallagalla.

Sphaerophoron compressum Ach. Method. Lich. 135. 1803.

Since Acharius cited both Lichen melanocarpus and L. fragilis in synonomy, S. compressum must be lectotypified.

Sphaerophoron coralloides var. congestum Lamy, Bull. Soc. Bot. France 25: 349. 1878. Original material: France, Mont-Dore et la Haute-Vienne.

Sphaerophoron globiferum var. depauperatum Müll. Arg. Mission Scientif. Cap Horn 10: 145. 1888. Original material: Chile, Bahia Orange, Dr. Hyades; Cap Horn, Dr. Hahn.

Material from one of these collections will have to be selected as the lectotype.

Lichen fragilis β elatior G. Web. Spicil. Flor. Goettingensis 206. 1778. Original material: Several specimens are listed in synonomy and this taxon requires lectotypification.

Sphaerophoron fastigiatulum Nyl. Mem. Soc. Sci. Nat. Cherbourg 5: 93. 1857. (Nom. nud.). Original material: Caracas, Lindley 401.

Sphaerophorus globuliferus Balbis, Flor. Lyonn 2: 168. 1828. [=L. globiferus L.]

The spelling of this taxon is likely a misprint.

Sphaerophorus isousnica Sato. Misc. Bryol. Lichenol. 5: 27. 1969. Original material: New Zealand, Westland, Mt. Brewster, Sato 318 (Sato).

This species should probably be placed in synonomy with S. ramulifer as all specimens with isousnic acid have been found to belong to that species.

Sphaerophorus globiferus var. lacunosus Tuck. U. S. Explor. Exped. 1838-42 17: 116. 1862. Original material: Chile, Bahia Orange.

Sphaerophorum coralloides var. laxum Turn. Specim. Lichenogr. Brit. 2: 110. 1839. Original material: Britain.

Sphaerophorus australis var. macrophyllus Zahlbr. Akad. Wiss. Wien, Math.-Naturwiss. Kl., Denkschr. 104: 259. 1941. Original material: New Zealand, North Island, Mt. Heehn, Tararua Range, Zotov Z.A. 475.

Sphaerophoron tenue f. majus Kremp. Verh. K.K. Zool.-Bot. Ges. Wien 26: 436. 1876. (Nom. nud.). Original material: Chile, Puerto Gallant.

Sphaerophoron polycarpum Col. Trans. & Proc. New Zealand Inst. 16: 361. 1884. Original material: New Zealand, North Island, near Norsewood, 1883 Colenso.

Sphaerophorus australis var. proliferus F. Wils. J. Linn. Soc., Bot. 28: 370. 1891. Original material: Australia, Victoria.

Sphaerophorus fragilis f. *pulviniformis* Vain. Acta Soc. Fauna Fl. Fenn. 57(1): 11. 1927. Original material: Three specimens are cited so this taxon must be lectotypified.

Sphaerophorus coralloides f. *pulvinata* Hav. in Lynge, Bergens Mus. Aarbok. 9. 1909. Original material: Norway, *Havaas 383*.

Sphaerophorus globosus var. *recurvus* Wade, Bryologist 57: 228. 1954. Original material: Greenland, Isersiutilik, 1928 *Trapnell*.

Sphaerophoron tenerum var. *stereocauloides* Nyl. Mem. Soc. Sci. Nat. Cherbourg 5: 93. 1857. (Nom. nud.). Original material: New Zealand.

Lichen sterilis Ach. Lichenogr. Suec. Prodrom. 211. 1798.

Lichen fragilis L. and *L. caespitosus* Roth. are cited in synonomy with *Lichen sterilis* so lectotypification is required.

Sphaerophorus compressus var. *subaustralis* Vain. Ann. Acad. Sci. Fenn., Ser. A. 15(6): 318. 1921. Original material: Philippines.

Several specimens are cited so a specimen must be selected as the lectotype.

Sphaerophorus globosus f. *subcoralloides* Vain. Acta Soc. Fauna Fl. Fenn. 57(1): 8. 1927. Original material: Insula Kuulakaenen, *C.E. Boldt* s.n.

Sphaerophoron vividulum Col. Trans. & Proc. New Zealand Inst. 17: 263. 1885. Original material: New Zealand, North Island, forests near Norsewood, Waipawa Co., 1880-84 *Colenso*.

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Sphaerophorus cuneatus (Stirt.) Murr. Trans. Roy. Soc. New Zealand 88(2): 186. 1960. = *Calycidium cuneatum* Stirt. Proc. Roy. Philos. Soc. Glasgow 10: 292. 1877. (See page 6).

Sphaerophoron complanatum Hook. f. et Tayl. London J. Bot. 3: 654. 1844. = *Siphula complanata* (Hook, f. et Tayl.) Comb. nov.

Although the combination *Siphula complanata* has previously been published (R. Santesson, 1968; J. Santesson, 1967) the transfer has not been validly published as the basionym was not indicated (Art. 33; Stafleu, 1972).

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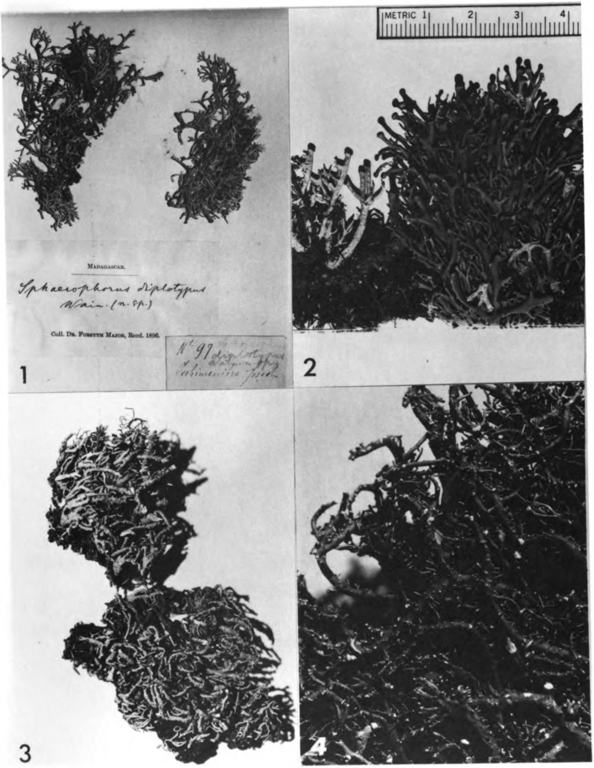
Figure 2. Sphaerophorus dodgei Ohlsson. (Imshaug 42952; holotype, MSC).

Figure 3. Sphaerophorus formosanus (Zahlbr.) Asah. (Asahina F274; isotype, TNS).

Figure 4. Isidioid structures occurring along the lamina of S. formosanus (Zahlbr.) Asah. (Asahina F274; isotype, TNS).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MADAGASCAR.
Sphaerophorus diplotypus
Wain. (n. sp.)
Coll. Dr. Forsyth Major, Recd. 1896.
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3
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Figure 5. *Sphaerophorus kinabaluensis* (Sato) Ohlsson. (*Hale 286561* isotype, TNS).

Figure 6. Typical material of *S. kinabaluensis* (Sato) Ohlsson, showing the subapically oriented mazaedia. (*Hale 29266*; US).

Figure 7. *Sphaerophorus insignis* Laur. (*Sieber* s.n.; lectotype, BM).

Figure 8. Lower surface and apothecia of *S. insignis* Laur., showing the ventrally oriented and partially covered apothecia. (1854 *Hampe*; holotype of *Sphaerophorus ceranoides* Hampe).

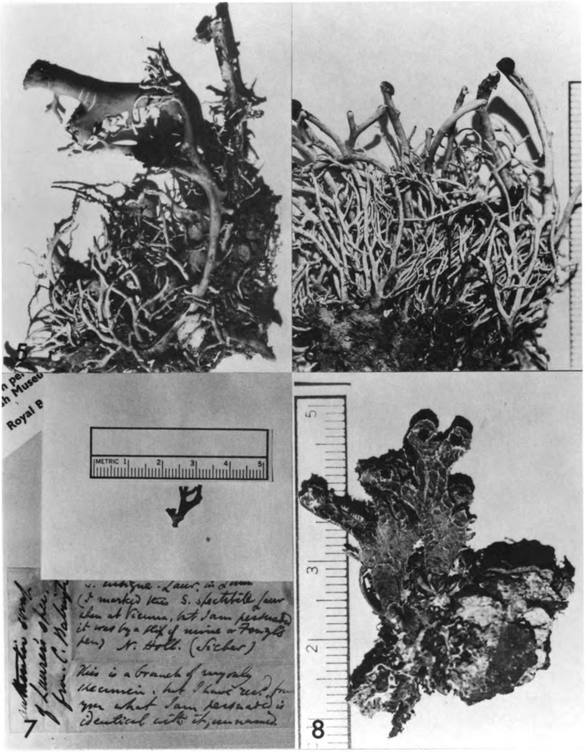
METRIC 1 2 3 4 5
(I marked this S. spectabile Laur. when at Vienna, but I am persuaded it was by a slip of mine or Fenzl's pen) N. Holl. (Sieber)
This is a branch of my only specimen, but I have recd. from you what I am persuaded is identical with it, unnamed.
7
8

Figure 9. Sphaerophorus imshaugii Ohlsson. (Imshaug 52368; holotype, MSC).

Figure 10. Sphaerophorus melanocarpus ssp. hawaiiensis Ohlsson (Heller 2813; holotype, MSC).

Figure 11. Sphaerophorus microsporus Ohlsson. (Imshaug 48120; holotype, MSC).

Figure 12. Isidioid branchlets near the apothecium of S. microsporus Ohlsson. (Imshaug 48120; holotype, MSC).

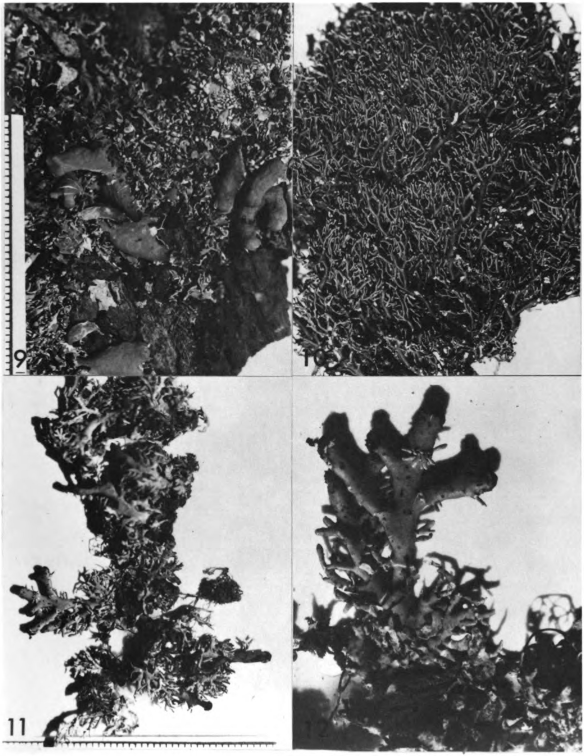
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Figure 13. Sphaerophorus madagascareus Nyl. (Pool s.n.; isotype, BM).

Figure 14. Laminal apothecia of S. madagascareus Nyl. (Pool s.n.; isotype, BM).

Figure 15. Sphaerophorus patagonicus (Dodge) Ohlsson. (Imshaug 52629; MSC).

Figure 16. Sphaerophorus murrayii Ohlsson. (Harris 6343; holotype, MSC).

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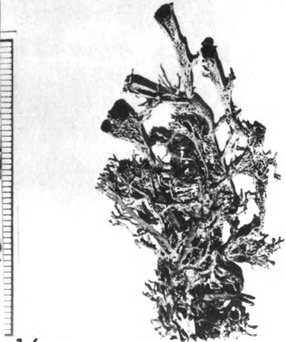

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Figure 17. Sphaerophorus macrocarpus Ohlsson. (Harris 6241; holotype, MSC).

Figure 18. Sphaerophorus ramulifer Lamb. (Lamb 5977; holotype, CAN).

Figure 19. Material indicated as 3 is the lectotype material of Sphaerophorus scrobiculatus (Bab.) Sato. (Colenso s.n.; lectotype, BM); specimen 4 is Sphaerophorus insignis Laur.

Figure 20. Sphaerophorus stereocauloides Nyl. (1867 Knight; holotype, H-Nyl. 40395).

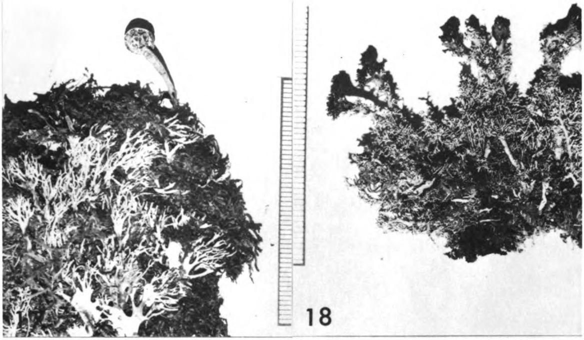

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Figure 21. "Coccotrema" unknown, crystals in G.A.o-T.

Figure 22. SEM photograph of Calycidum cuneatum Stir. Cross-section of thallus branch. (Imshaug 48115, MSC).

Figure 23. SEM photograph of a spore from S. insignis Laur. Spore surrounded by a heavy carbonaceous material. (Imshaug 47240, MSC).

Figure 24. "Scrobiculatus" unknown, crystals in G.E.

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Figure 25. Surface view.

Figure 26. LS view. Medullary hyphae heavily gelatinized and fused forming a dense central strand.

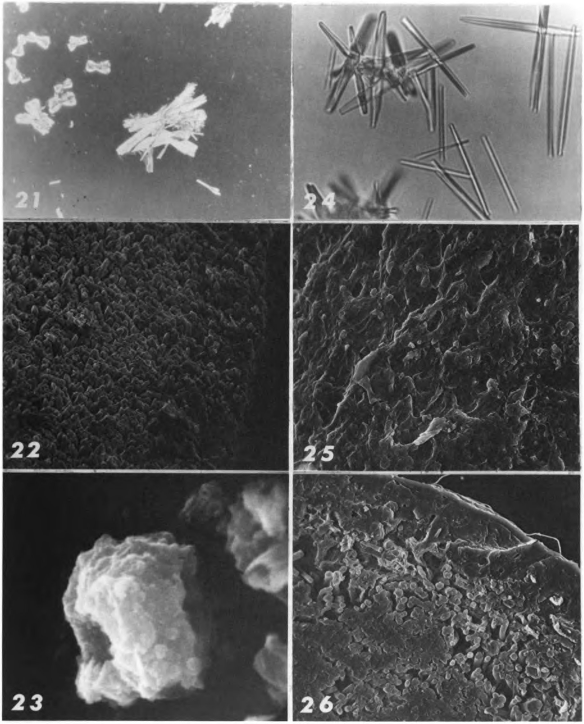
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Figure 27. Surface view.

Figure 28. XS view. Medullary hyphae fused near the cortex layer, becoming lax towards the center.

Figure 29. LS view. Branched hyphae in the medulla and algae beneath the cortex (see a).

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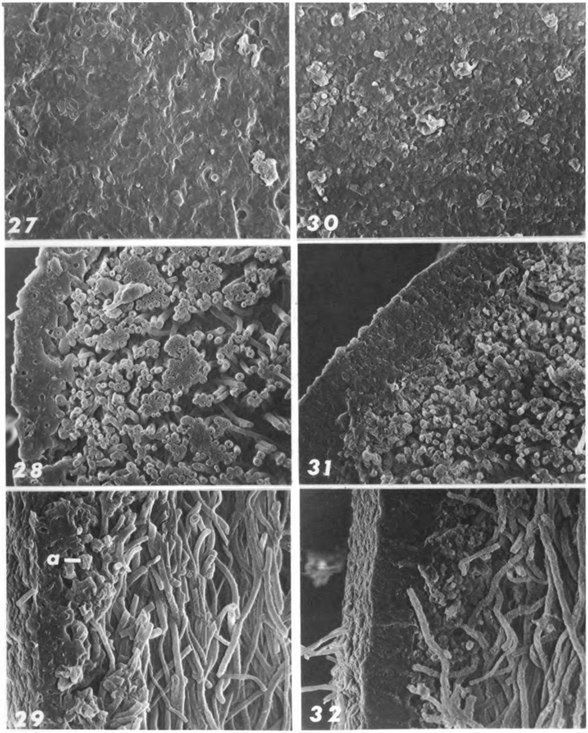
Figure 30. Surface view.

Figure 31. XS view.

Figure 32. LS view. Longitudinally arranged hyphae surrounded by numerous crystals.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Figures 33-35. SEM photographs of S. patagonicus (Dodge) Ohlsson. (Imshaug 52629, MSC).

Figure 33. Surface view.

Figure 34. XS view near the upper surface.

Figure 35. LS view.

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Figure 36. Surface view.

Figure 37. XS view. Medulla composed of heavily gelatinized and fused hyphae forming a solid central strand. Cortical layer thin and irregular.

Figure 38. LS view.

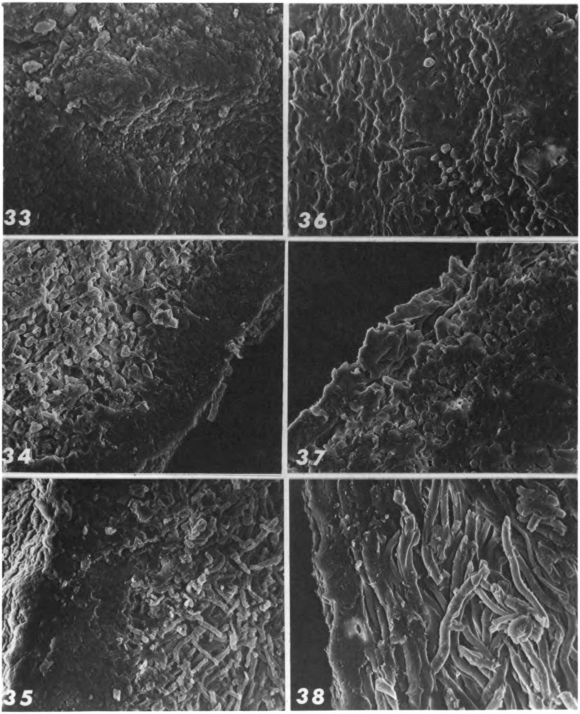
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Figure 39. Distributional areas of three subgenera of Sphaerophorus. Subgenus Sphaerophorus — · —; Subgenus Bunodophorus ——; Subgenus Aghimus • • •.

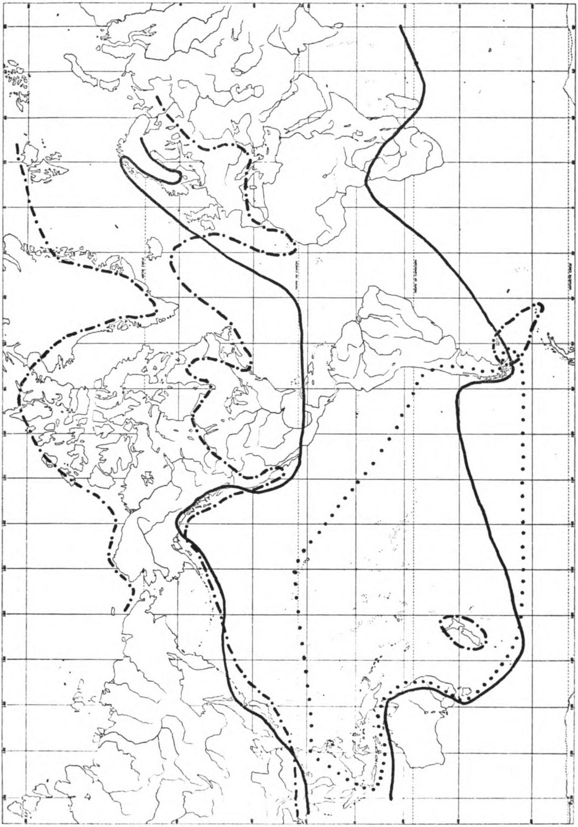


Figure 40. Distribution of Sphaerophorus tener Laur.

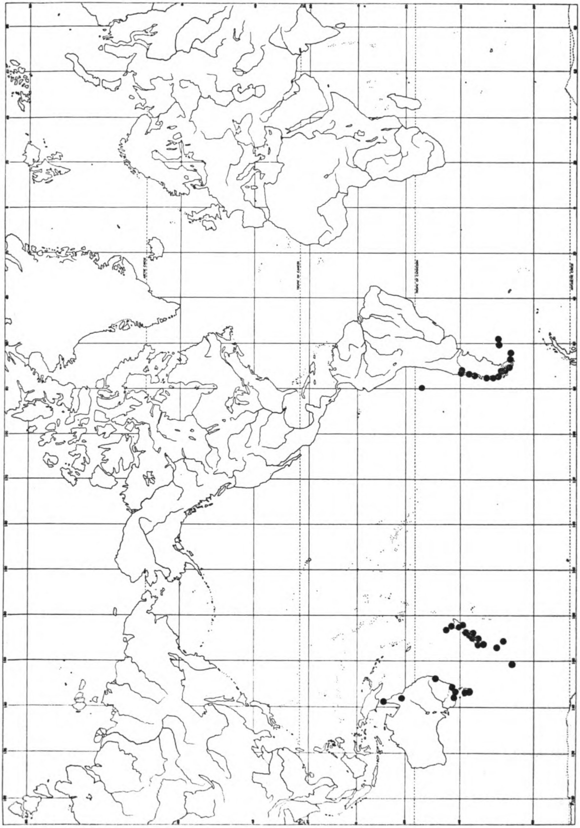


Figure 41. Distribution of _Sphaerophorus fragilis_ (L.) Pers. Chemotype I, containing sphaerophorin and hypothamnolic acid.

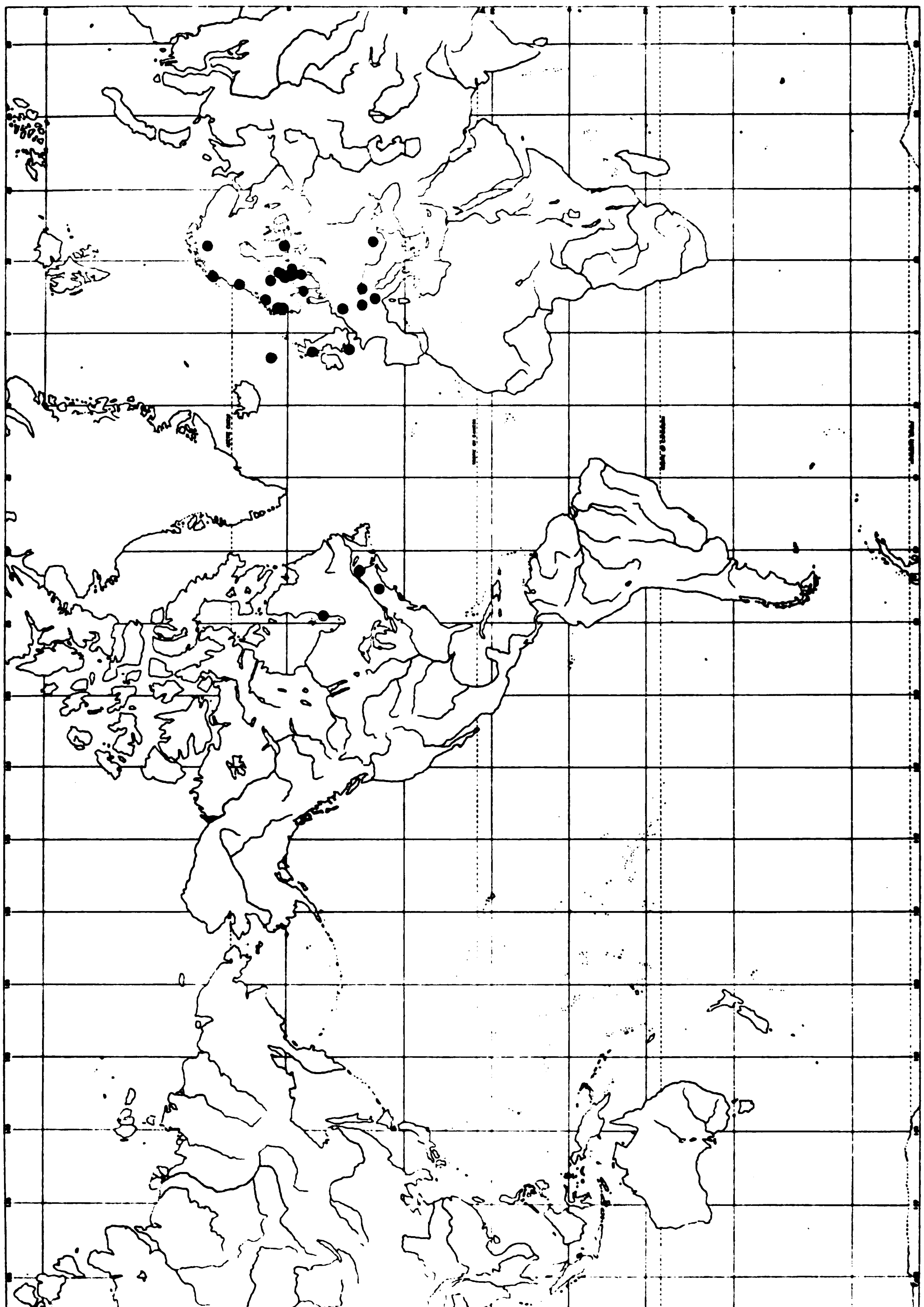


Figure 42. Distribution of Sphaerophorus fragilis (L.) Pers. Chemotype II, containing sphaerophorin.

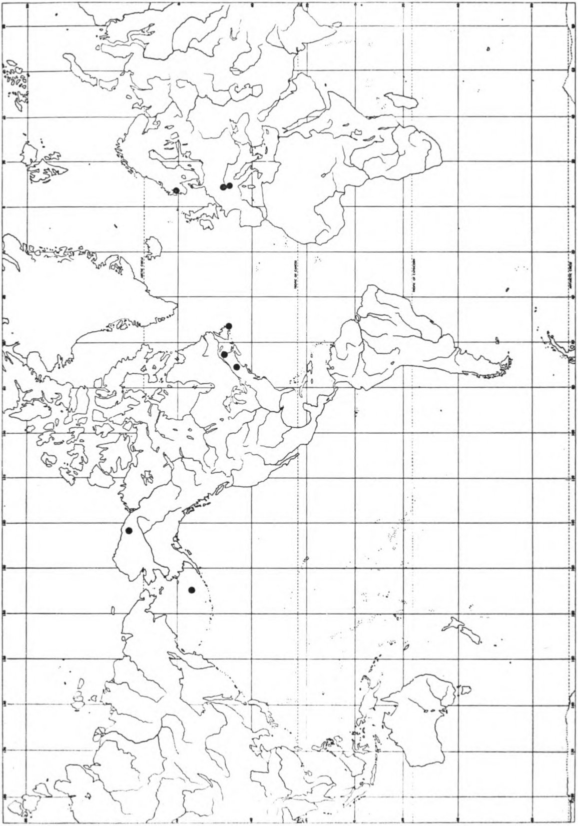
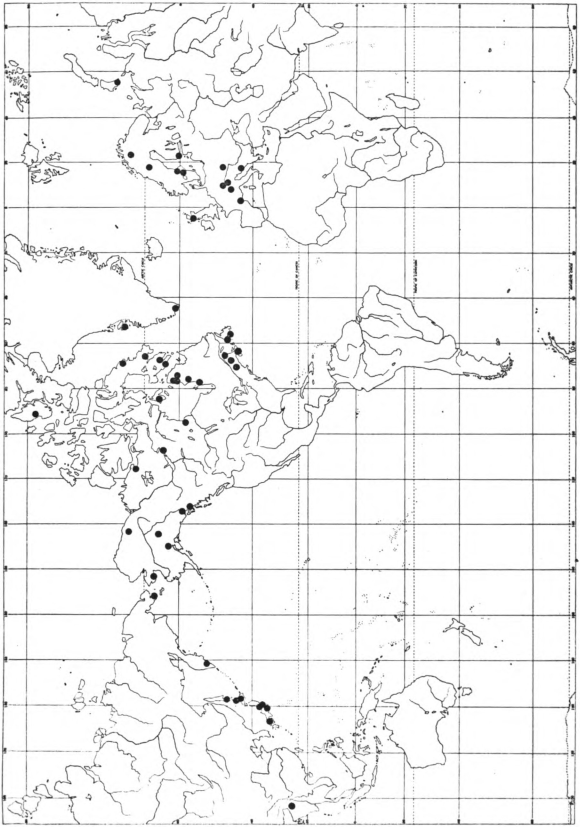


Figure 43. Distribution of Sphaerophorus fragilis (L.) Pers. Chemotype III, containing sphaerophorin and squamatic acid.



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ic acid.

Figure 44. Distribution of Sphaerophorus fragilis (L.) Pers. Chemotype IV, containing sphaerophorin, squamatic acid, and hypothamnolic acid.

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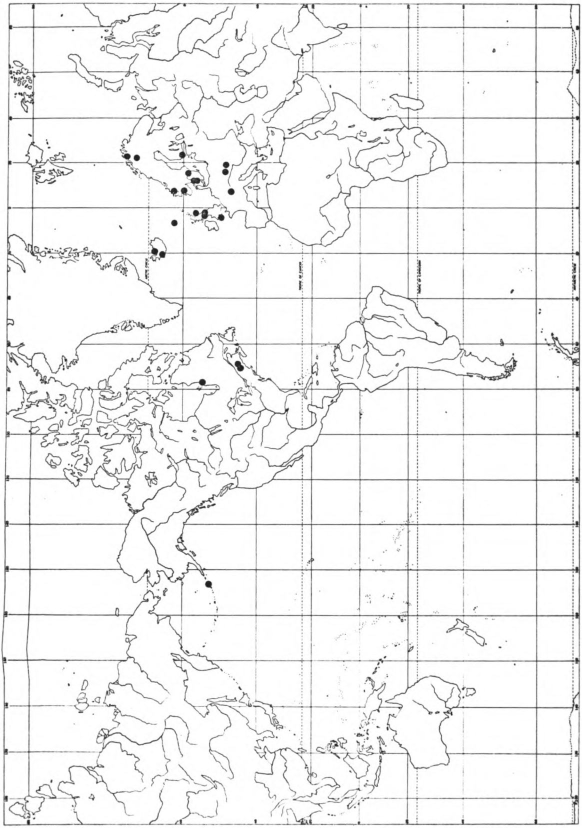


Figure 45. Distribution of <u>Sphaerophorus globosus</u> (Huds.) Vain. Chemotype I, containing sphaerophorin.

Vain. Cher.

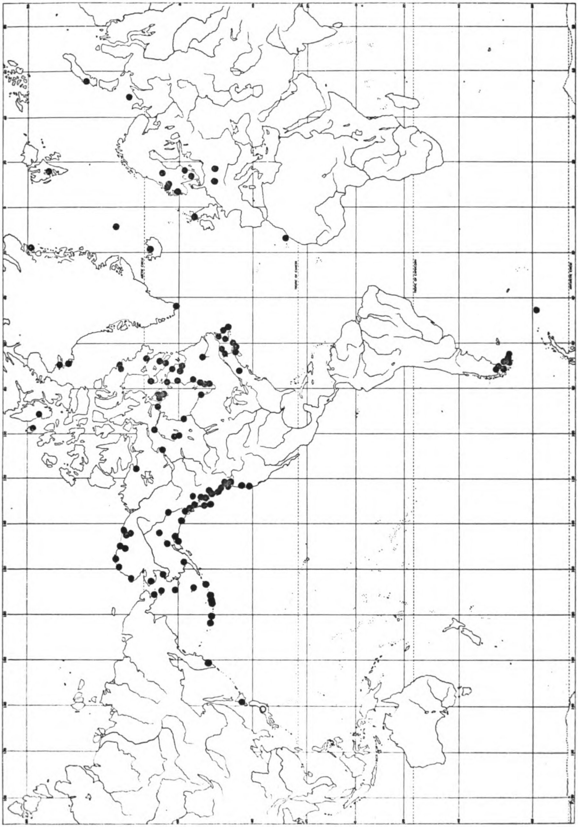


Figure 46. Distribution of Sphaerophorus globosus (Huds.) Vain. Chemotype II, containing sphaerophorin and thamnolic acid.

Vain.
acid.

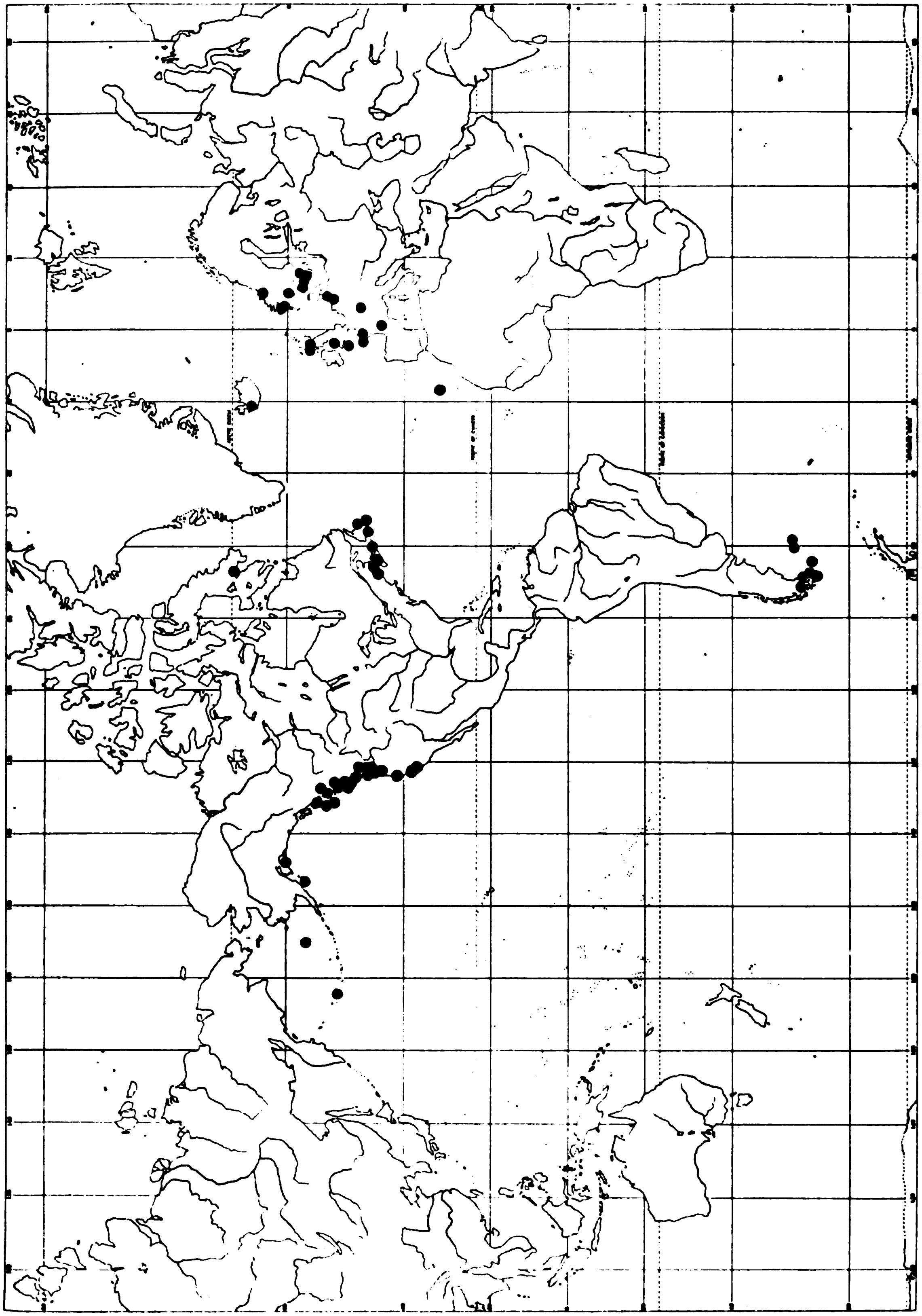


Figure 47. Distribution of Sphaerophorus globosus (Huds.) Vain. Chemotype III, containing sphaerophorin and squamatic acid.

Vain. Chem-
c acid.

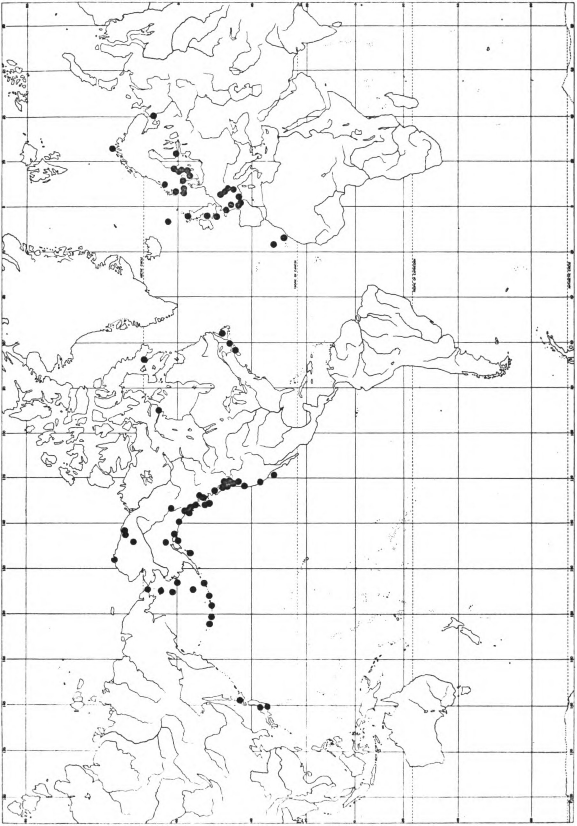
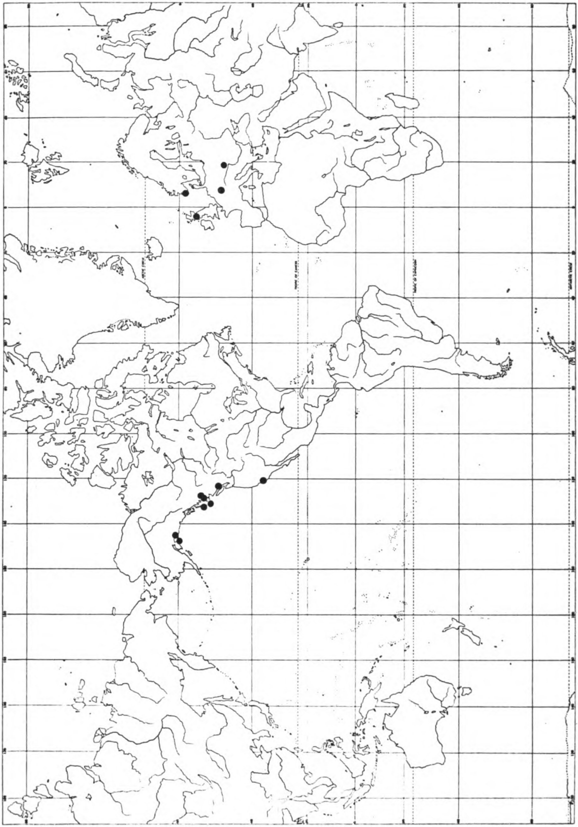


Figure 48. Distribution of Sphaerophorus globosus (Huds.) Vain. Chemotype IV, containing sphaerophorin and hypothamnolic acid.



| Vain. Chem-
nolic acid.

Figure 49. Distribution of _Sphaerophorus globosus_ (Huds.) Vain. Chemotype V, containing sphaerophorin, squamatic acid and hypothamnolic acid.

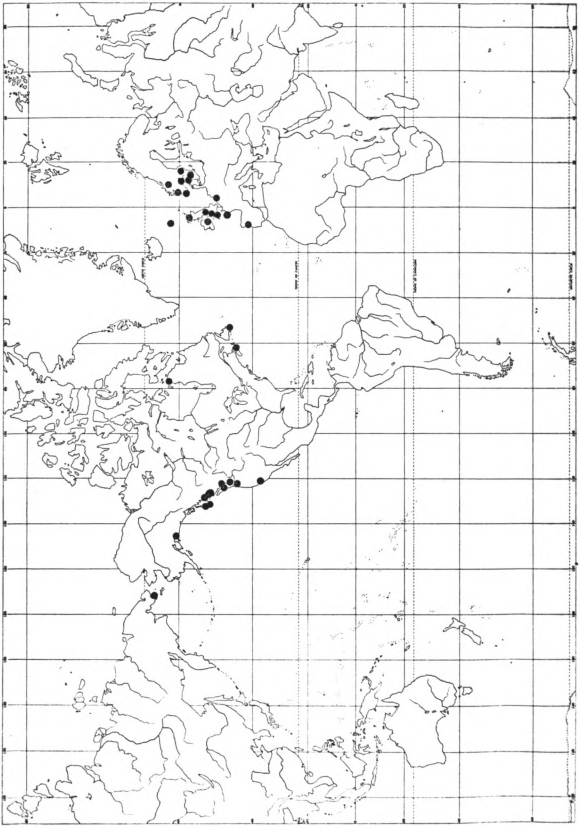


Figure 50. Distribution of Sphaerophorus globosus (Huds.) Vain. Chemotype VI, containing sphaerophorin, squamatic acid and thamnolic acid.

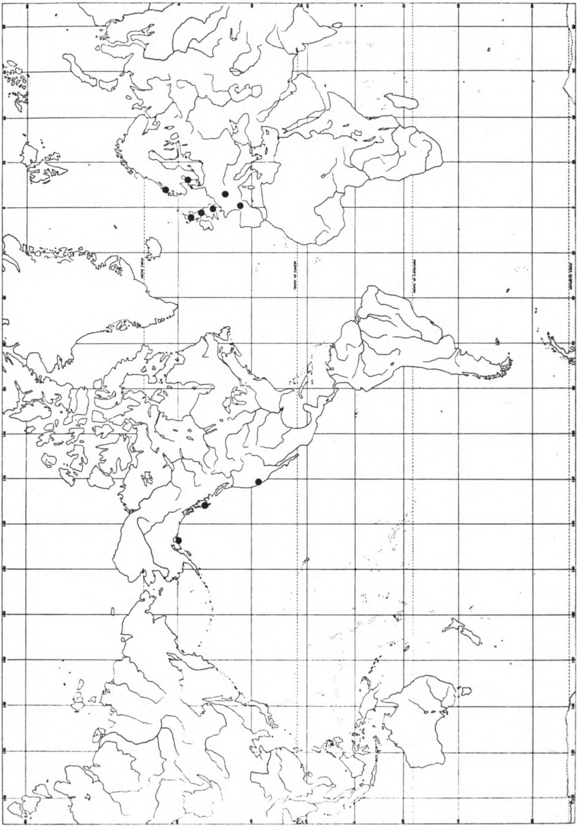


Figure 51. Distribution of Sphaerophorus diplotypus Vain.

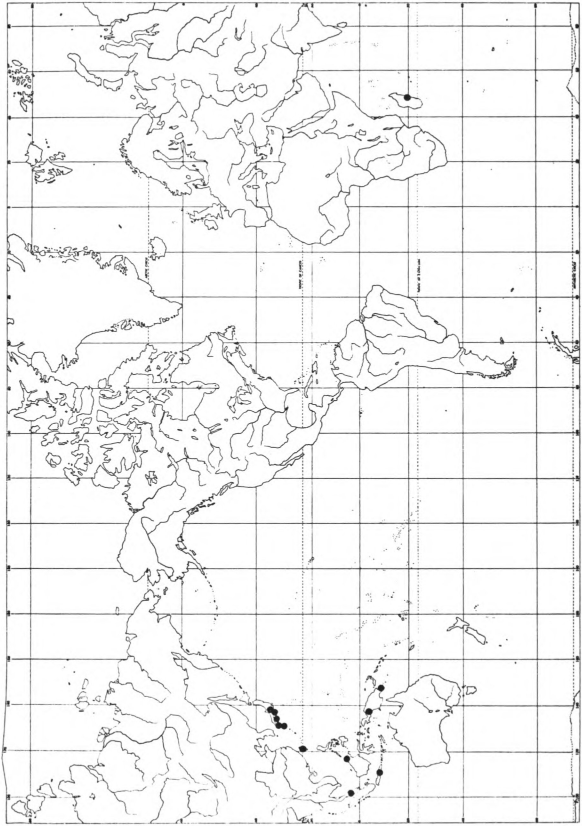


Figure 52. Distribution of Sphaerophorus formosanus (Zahlbr.) Asah.

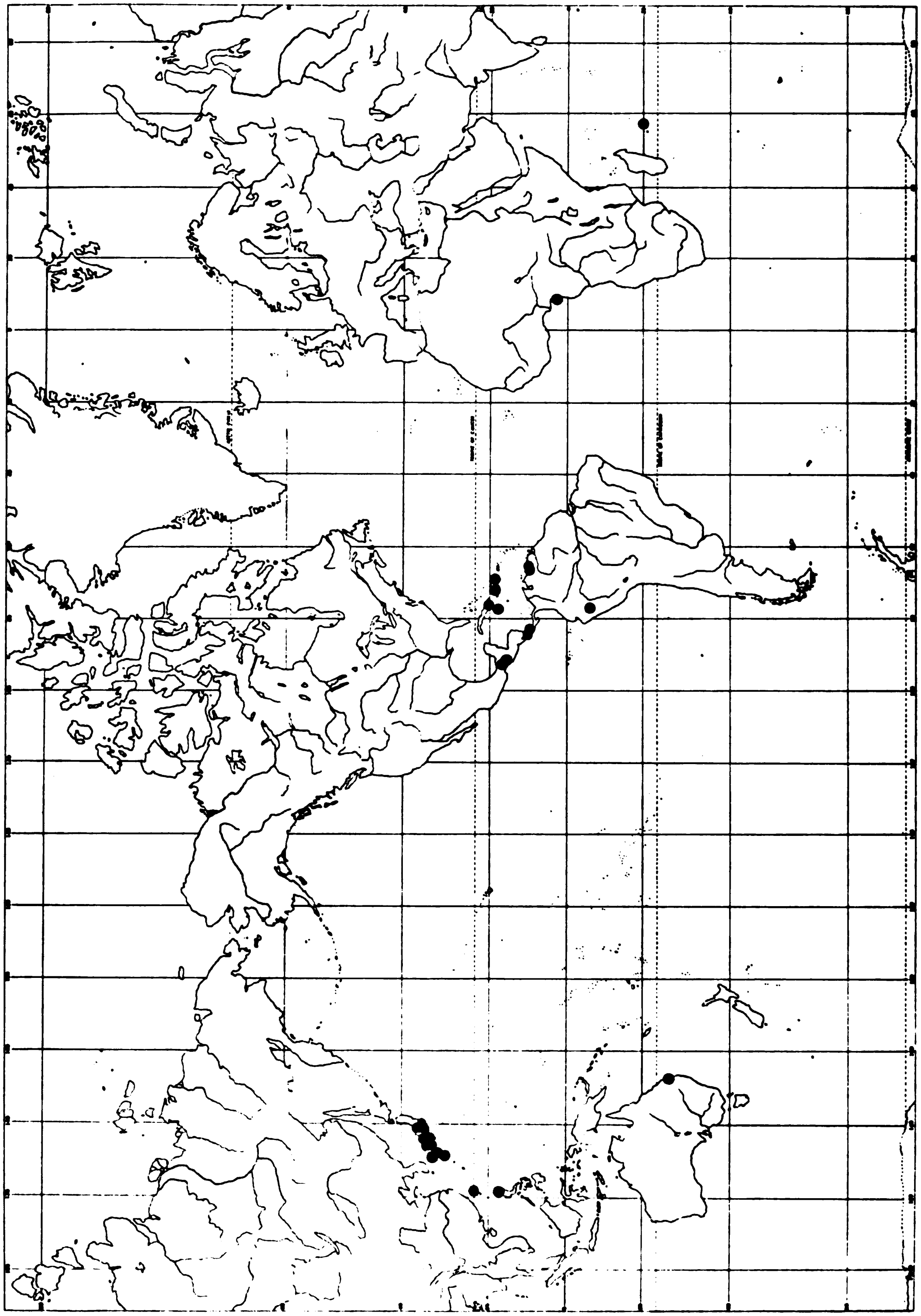


Figure 53. Distribution of Sphaerophorus kinabaluensis (Sato) Ohlsson.

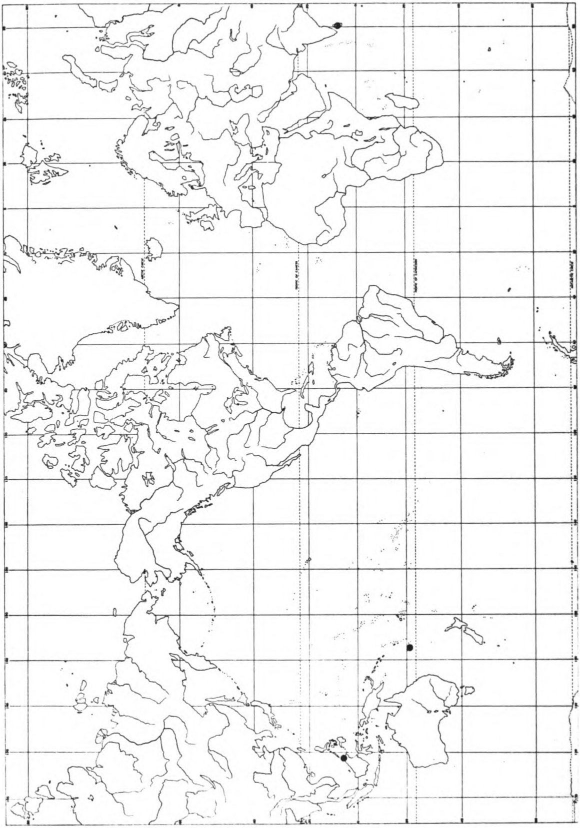


Figure 54. Distribution of _Sphaerophorus_ _melanocarpus_ (Sw.) DC. Chemotype I, containing sphaerophorin, stictic acid and constictic acid.

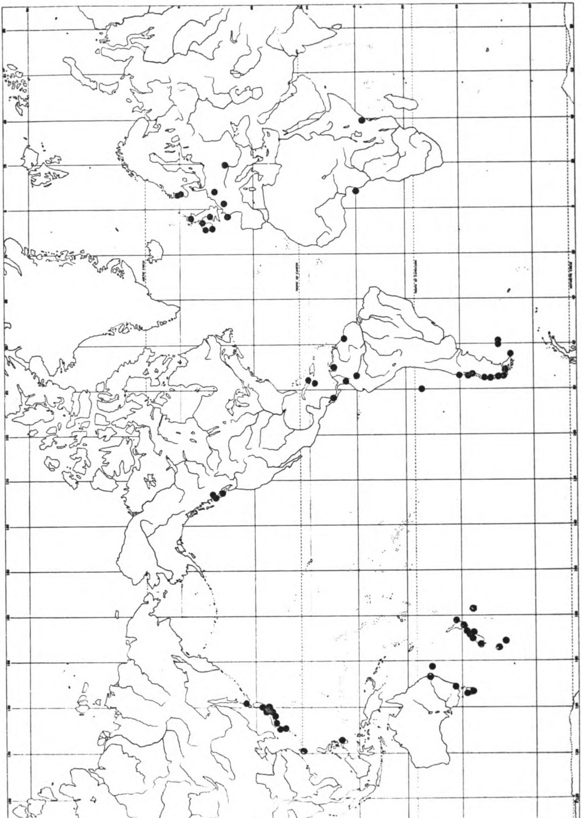


Figure 55. Distribution of *Sphaerophorus melanocarpus* (Sw.) DC. Chemotype II, containing sphaerophorin.

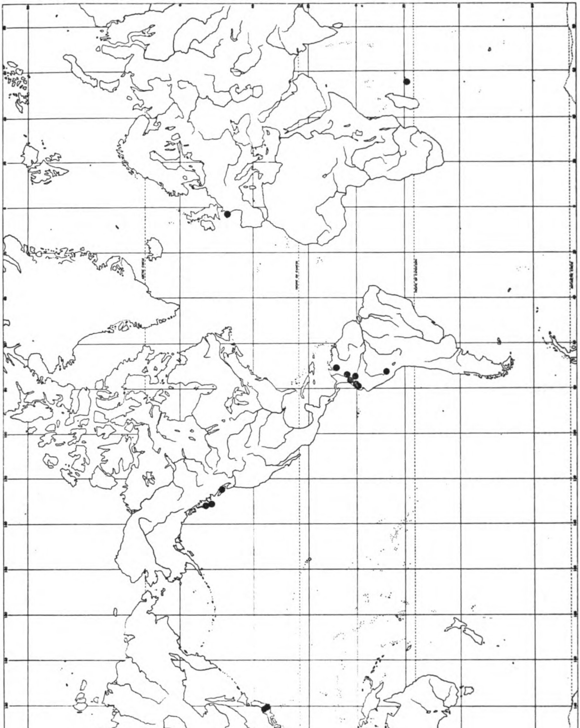


Figure 56. Distribution of Sphaerophorus ramulifer Lamb. Chemotype I, containing isousnic acid and sphaerophorin.

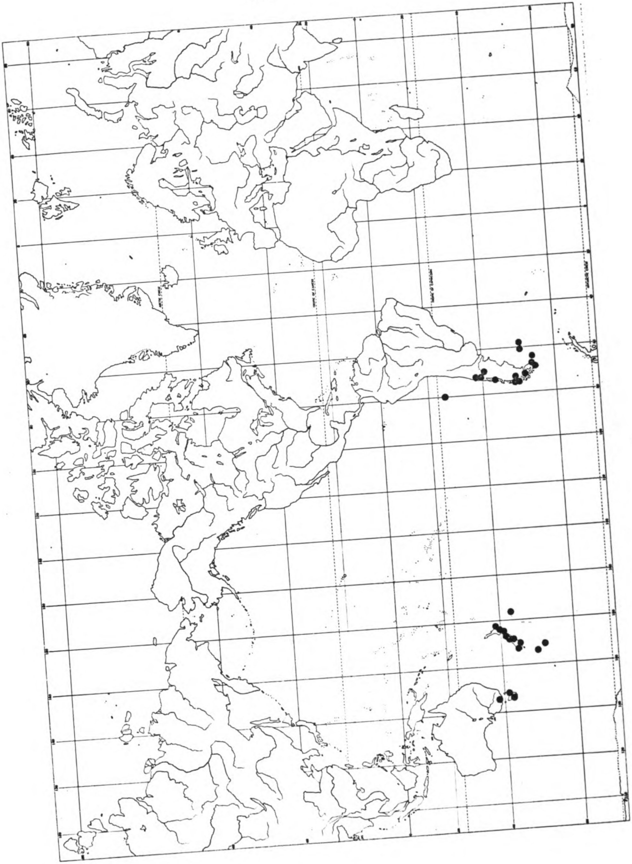
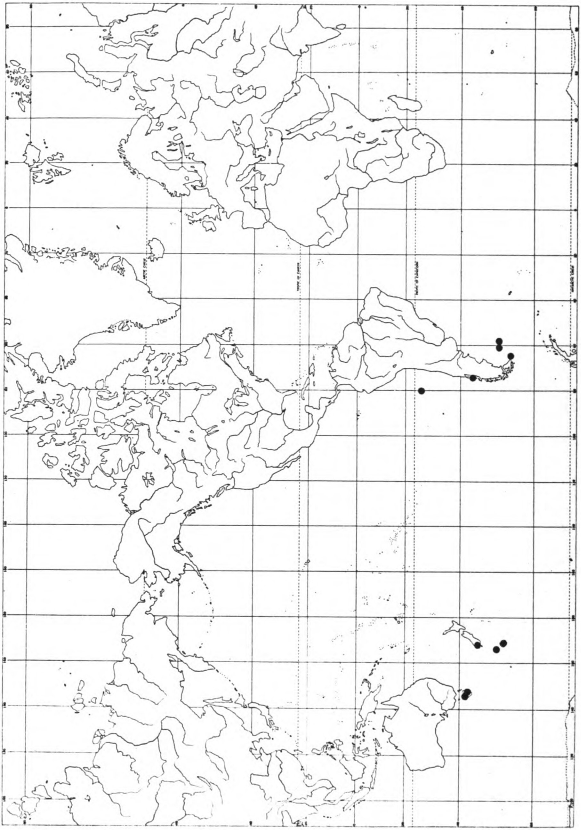


Figure 57. Distribution of Sphaerophorus ramulifer Lamb. Chemotype II, containing isousnic acid, sphaerophorin, stictic acid and constictic acid.



b. Chemotype
ictic acid and

Figure 58. Distribution of <u>Sphaerophorus</u> <u>ramulifer</u> Lamb. Chemotype IV, containing isousnic acid, sphaerophorin, and "coccotrema" unknown.

hemotype :
occotrema'

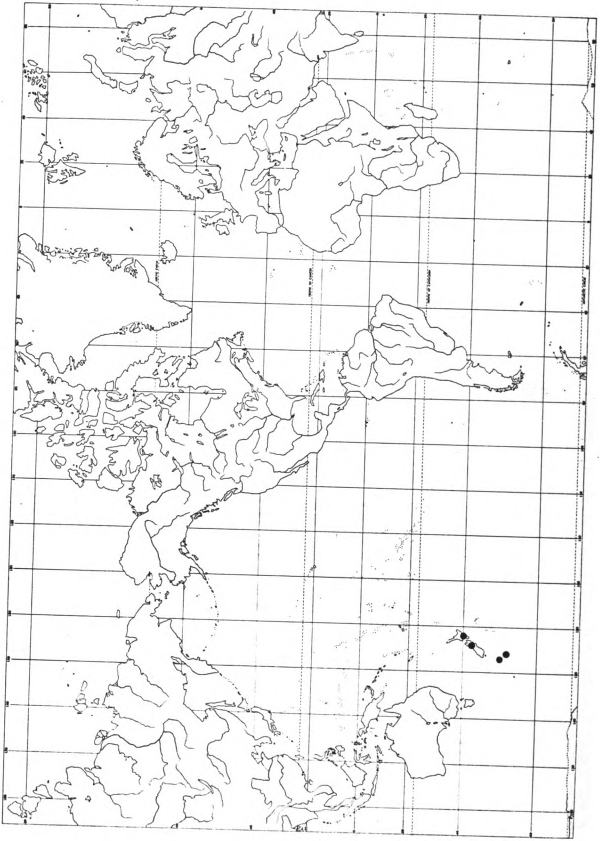


Figure 59. Distribution of *Sphaerophorus imshaugii* Ohlsson.

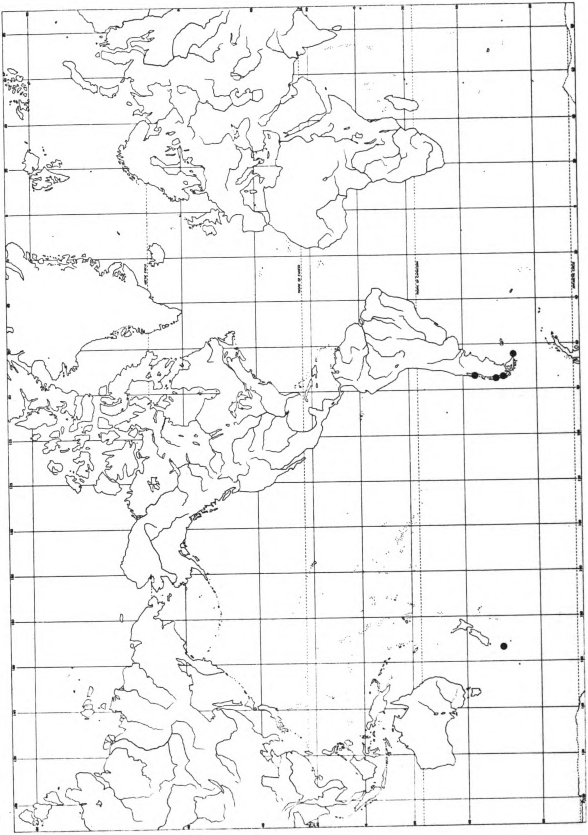


Figure 60. Distribution of Sphaerophorus insignis Laur.

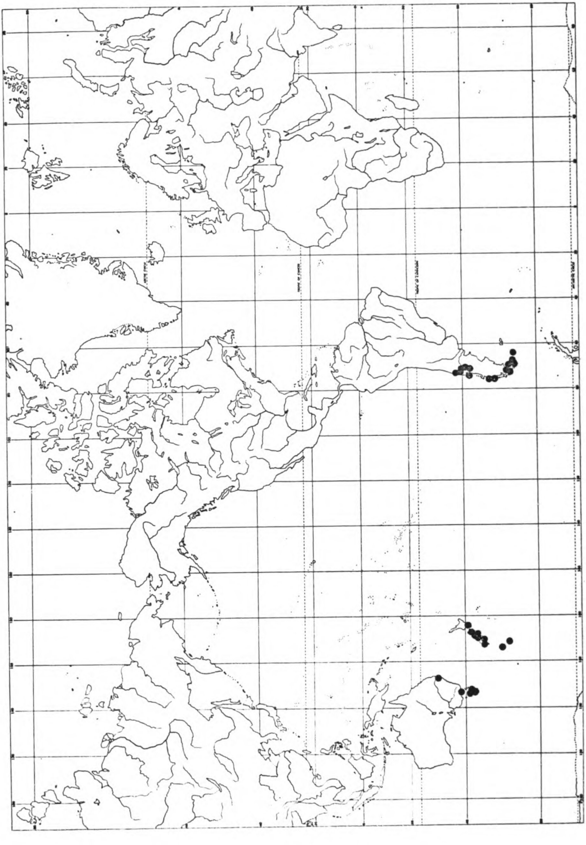


Figure 61. Distribution of Sphaerophorus macrocarpus Ohlsson.

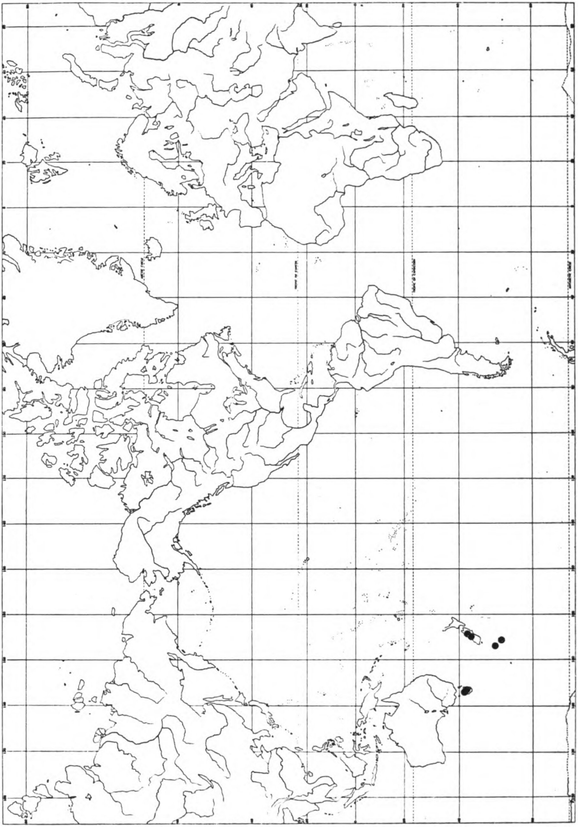


Figure 62. Distribution of _Sphaerophorus_ _murrayii_ Ohlsson.

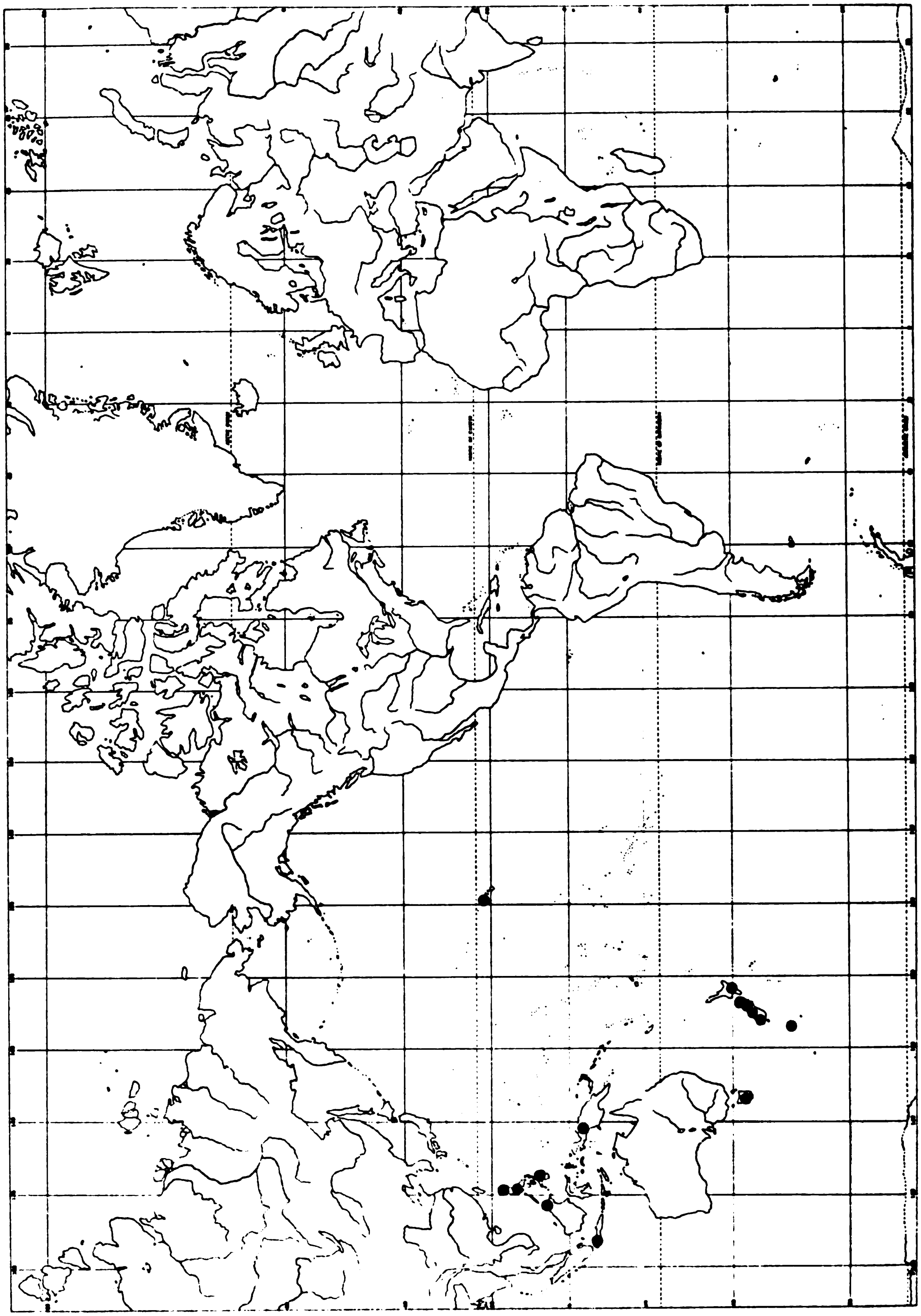
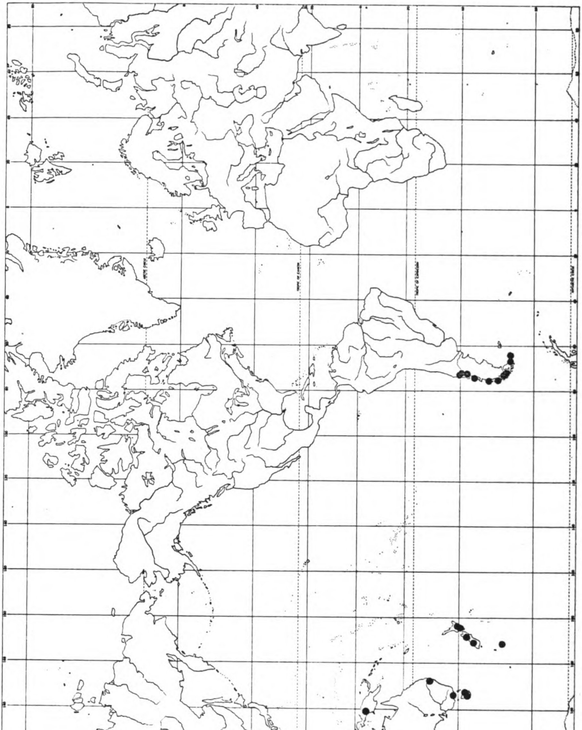


Figure 63. Distribution of Sphaerophorus patagonicus (Dodge) Ohlsson.



odge) Ohlssc.

Figure 64. Distribution of Sphaerophorus scrobiculatus (Bab.) Sato.

ab.) Satc