OBSERVATIONS ON THE BIOLOGY OF SOME SAND-DUNE FUNGI.

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The following notes were for the most part made during July 1917, on some species of Agarics found growing on sand-dunes near the village of Oxwich, on the Gower coast, South Wales. Very little work has been done on the fungus-flora of sand-dunes, though Wheldon's list of the fungi of the Lancashire dunes* shows how surprisingly large this fungus-flora may be. It has been thought worth while to place these few observations on record, as offering some suggestion as to the means by which delicate Agarics manage to exist in what is apparently so unfavourable a habitat.

Psilocybe ammophila Mont.

This species, which is absent from Wheldon's list, occurs abundantly on the Gower dunes in the summer months, after rain. It grows on the exposed slopes of high dunes, usually about the tufts of Marram grass (*Ammophila arundinacea*). When dug out the stem appears to be clavately swollen below, and continued downwards as a tapering, rooting base. As a matter of fact the stipe itself is of equal diameter throughout, as may be seen in a vertical section, and it terminates abruptly an inch or so beneath the surface of the sand. The apparently clavate lower half, and the long root-like base are due to a web of fine hyphæ mixed with particles of sand, which surrounds the buried part of the stem, and is continued downwards as a gradually tapering cord. This cord, however, is very different in structure from an ordinary mycelial cord. Consisting merely of loosely interwoven hyphæ, the interstices being filled with sand, it is extremely fragile, and hence difficult to trace to its point of origin.

After many attempts to dig out the underground portion of the fungus, I was at length able to satisfy myself that it is always connected with buried, decaying leaves of the Marram grass. Only occasionally, however, does it

*H. J. Wheldon in Lancash. and Chesh. Naturalist, 1914.

arise from a single leaf. It may do so if the leaf is near the surface, in which case the sandy cord is seen to be directly connected with a weft of hyphæ mixed with sand particles which surrounds the dead leaf. In the majority of cases the points of origin are more deeply seated. The "root" tapers to about the thickness of medium twine, and then, if great care has been taken in excavating, is found to fork or branch repeatedly. It is as a rule impossible to trace the ultimate ramifications on account of their fineness and fragility, but in a few cases I was successful in tracing a branch to a dead *Ammophila* leaf, which was covered by a fine weft of hyphæ. It appears therefore that the mode of nutrition of *Psilocybe ammophila*, though on a much smaller scale, is similar to that of *Collybia platyphylla*, in which a single sporophore is connected by a complicated branching system of underground cords with various decaying twigs, leaves, etc.

Geopyxis ammophila Sacc. of which an interesting description was published by Trail in the Annals of Scottish Natural History, 1893, pp 37-40, is probably similar in its mode of life. This species was noted by Trail to have an elongated "rooting stem," which is exceedingly fragile. In this case the grass with which it was associated was *Elymus*.

Coprinus Friesii Quél.

Another interesting Agaric found in July was a small species of *Coprinus*, apparently *C. Friesii* Quél. This occurred in one of the numerous hollows in these dunes which are liable to inundation at spring-tides from the overflowing of a small stream. In the bottom of such hollows the only phanerogamic vegetation is usually *Juncus maritimus* with occasional plants of *Glaux maritima*.

The *Coprinus* grew gregariously in patches, on the slopes of the tiny sand-hillocks formed round the tufts of *Juncus*. At first sight it appeared to be growing from the sand, but on investigation it was found that the clusters of fruit-bodies always arose from the dead stems of the *Juncus*, exactly at the surface of the sand. Hitherto I have only found this fungus on one occasion, which was on the day after a whole day's rain. The sand beneath the surface and the buried *Juncus* stems were saturated with moisture. On returning to the same spot a few days later, after a dry interval, I was only able to see a few shrivelled fruit bodies.

This fungus agrees well in macroscopic characters and in habitat with Quélet's original description of *C. Friesii*; it also agrees in micro-characters with Lange's description in his monograph of the *Coprini* of Denmark and with the

description of *C. tigrinellus* Boud., which is said to be very close to *C. Friesii*. Quélet described *C. Friesii* as growing on dead but still erect stems of grasses. Lange finds it typically on dead grass, and also a form on dead *Phragmites* straw, and another form on bits of straw from horse-droppings. *C. tigrinellus* Boud. grew on dead erect stems of *Carex*, and has been recorded in this country both on *Carex* and on *Juncus*.† All these forms thus agree in growing on dead erect stems of grasses, sedges, or rushes, in damp places. They agree closely also in macro- and microscopic characters, the chief point distinguishing *tigrinellus* from *Friesii* being that the flecks on the pileus are deep brown instead of white. As in my specimens the colour of the tomentum varied from white to rust-brown, it seems probable that *C. tigrinellus* and *C. Friesii* are hardly specifically distinct. The name *Friesii* is used as being the earlier.

Bolbitius tener Berk. and *Galera rubiginosa* Fr.

In the same hollow where the *Coprinus Friesii* grew, there occurred two small brown-spored Agarics, *Bolbitius tener* Berk. (distinguished from the more common species of *Bolbitius* by its white and less fragile pileus), and *Galera rubiginosa* Fr.

These grew directly from the sand, and were not connected in any way with any phanerogamic plant. In the course of digging up some specimens it was noticed that the top layer of sand came away easily as a flat crust about $\frac{1}{2}$ in. in thickness. The fungi had no rooting base, the stipes ending abruptly in this upper crust of sand. Closer examination showed that the crust was slightly tinged green, and it was subsequently found that this colour was due to innumerable minute algae with which the sand was permeated. The algal layer consisted mainly of a species of *Oscillaria*, but a few unicellular green forms were also present.

These two species of Agarics, therefore, must have subsisted practically entirely on the small amount of humus derived from the algal crust. The *Galera* grew gregariously, in considerable quantity. *Bolbitius tener* was also represented by a number of specimens, but was not so abundant as *Galera rubiginosa*.

Inocybe dulcamara Fr. and *I. eutheles* B. and Br.

In the "slacks" or damp hollows of the dunes, and on dune-pasture, where phanerogamic vegetation is more

†Naturalist, 1908, p. 320.

abundant, the presence of Agarics is less difficult of explanation. Where there is a close carpet of grass, with other small flowering plants, mosses, liverworts, etc., there is necessarily a fair amount of humus mixed with the surface layer of sand. Consequently a number of species of fungi are to be found in such habitats. At the time these notes were made, in July, the most abundant species in the "slacks" was *Inocybe dulcamara* Fr. It grew for the most part on the ground beneath *Salix repens*, but specimens also occurred amongst the short grass in the open and in this position showed certain distinct variations, no doubt due to their greater exposure to light.

Specimens growing under the dwarf willow averaged about 1½ in. in diameter, but were occasionally larger. The rather fleshy pileus was tomentose-squamulose (not squarrosely scaly), and of a uniform rich tawny colour. When growing in the open the stem was shorter and the pileus smaller and more tough. The pileus of the sheltered specimens was practically always hemispherical and scarcely umbonate, whereas specimens in the open were more distinctly umbonate, and when old often showed an upturned margin. Furthermore, the tomentum, especially about the umbo, was in the exposed individuals aggregated to form little squarrose scales, of a distinctly darker brown than the margin of the pileus. These scales often eventually became rubbed off, leaving the pileus almost smooth and innately fibrous or strigose. Along with these external differences, a slight spore-variation was noticeable in the exposed specimens. In these the spore was inclined to be more obovate, or even somewhat triangular in shape, whereas in the sheltered specimens it was regularly elliptical. It is interesting to find such variations correlated with a distinct difference of exposure. In other respects, as to general aspect, absence of cystidia, type of gill edge, etc., the two forms agreed exactly, and were obviously variations within one species.

A single collection of *Inocybe eutheles* was made in the same situation, under *Salix repens*, but *I. rimosa*, which Wheldon notes as being abundant on the Lancashire dunes, was not present; at least at the time when I was able to examine the Gower dunes.

There is no doubt that if sand-dunes were examined thoroughly at all seasons of the year their fungus-flora would be found to be surprisingly rich, and much might be learnt as to the adaptation of species to these unpromising conditions.