ART. XXXIV.—*Studies in the Cyperaceæ;* by THEO. HOLM. XII. Segregates of *Carex filifolia* Nutt. (With eight figures in the text.)

WHILE engaged in a study of the alpine flora of the Rocky Mountains in Colorado last summer, we noticed a small *Carex*, which showed such a striking resemblance to *Elyna spicata*, that it required a careful analysis of the flower to decide whether it was this plant or, really, a *Carex*. It was unlike any other which we had seen heretofore in the mountains, but it occurred so abundantly on some bald mountain tops, that we never suspected it to be a "species nova." However, when we commenced to work up the material, it was soon learned that our plant was an old acquaintance, but that it had been placed under *Carex filifolia* Nutt. as a variety: *miser* (sic!) Bail. It never occurred to us that this plant could be in any way a form or variety of *C. filifolia*, and since the so-called variety "valida" of this same species from lower elevations was also in our collection, we felt induced to study them in order to find out how far they were related to each other. The result of our investigation is, that we can by no means look upon these plants as representing one species, nor being varieties, since they exhibit not a few distinct morphological characters, besides that, we have, also, found some important differences in their anatomical structure.

In later years anatomical studies have become very useful not only to the classification of plants in general, but also in view of the species themselves. And in a genus as large as *Carex* the morphological characters are often so indistinct and unimportant that it seems quite necessary to take the two together. The anatomical literature already possesses several works upon the structure of *Carices*, which may be seen from our references in previously published articles in this Journal. In the present case it is our intention to show how very important distinctions may be drawn from the structure of species which, viewed morphologically, were once considered as only one type with two varieties.

As regards *Carex filifolia* Nutt. this species is by Professor L. H. Bailey* placed under the *Sphæridiophoræ* of Drejer,† as a member of Tuckermann's "*Filifoliæ*,"‡ and next to *Carex scirpoidea* Michx. However, it is readily seen by compar-

* Bailey, L. H.: A preliminary synopsis of North American Carices (Proceed-Am. Acad. Arts and Sciences, 1886, p. 122).

† Drejer, S.: Symbolæ Caricologicæ. Kjöbenhavn, 1844, p. 9.

‡ Tuckermann, Edw.: Enumeratio methodica Caricum quarundam. 1843.

ing these two species, that the latter does not show any relationship to *C. filifolia*, but that it may be more naturally placed among the "*Montanæ*" of Fries,* and as one of the "*formæ hebetatæ*" of that section, as already pointed out by Drejer (l. c.). *Carex filifolia* is, on the contrary, one of the *Filifoliæ* Tuckm., and constitutes together with our *C. elynoides*, the only representatives of this group in North America. But it is, on the other hand, not so very certain whether the "*Filifoliæ*" are really to be placed under the *Sphæridiophoræ*, at least not if we emphasize this section as it was originally proposed by Drejer. This author does not attribute such characters to the *Sphæridiophoræ* as are included by Professor Bailey (l. c.).

Drejer does not speak of a "perigynium, firm or hard in texture, hairy or scabrous," but "perigynium membranaceum, pube hirsutie vel tomento vestitum," of which only the first character, the membranaceous perigynium (utriculus) is applicable to *C. filifolia*. Moreover, Drejer describes the bracts as "membranaceæ nervo dorsali excurrente herbaceo," which is not recognized by Professor Bailey, and which does not apply to *C. filifolia* either. The description of the utriculus: "rostro apice subbilobo" by Drejer is by Professor Bailey translated as "bifid." In other words, the *Sphæridiophoræ* of Drejer are not identical with the section of the same name by Professor Bailey. Therefore, Professor Bailey does not hesitate to place the broad-leaved, stoloniferous *Carex scirpoidea* Michx. side by side with *C. filifolia*, to which it shows no resemblance whatever.

The systematic position of Tuckermann's "*Filifoliæ*" yet remains to be settled, and these, no doubt, represent a group just as peculiar and isolated from the other *Carices* as is the case with the remarkable *Carex Fraseri* Andr. We must at present content ourselves in recognizing the *Filifoliæ* as a section rather than a subsection, and it may be of some service to further studies, when we in the following pages present a brief discussion of a species, which seems to be very closely related to *C. filifolia*, while eliminating another, which was formerly considered as an ally of this species. These segregates of *Carex filifolia* Nutt are:

Carex elynoides Holm (fig. 1).
(*C. filifolia* Nutt. var. *miser* Bail., not *C. miser* Buckl.)

Rhizome densely cespitose; culm 5 to 8^{cm} high, stiff, terete, sulculate, glabrous; leaves for the most part longer than the

*Fries, Elias: Summa vegetabilium Scandinaviæ. Upsala, 1846. Sectio I, p. 70.

FIGURE 1.—*Carex elynoides*, fruiting and flowering specimen; natural size.
FIGURE 2.—*Carex oreocharis*, natural size.
FIGURE A.—Scale of the male flower of *C. elynoides*, enlarged.
FIGURE B.—Scale of the female flower of same, enlarged.
FIGURE C.—Scale of the male flower of *C. oreocharis*, enlarged.
FIGURE D.—Scale of the female flower of same, enlarged.
FIGURE E.—Utriculus of same, enlarged.
FIGURE F.—Utriculus of same, enlarged.

culm, stiff, filiform, scabrous, their sheaths light-brown, persisting, not fibrillose; spike one, androgynous, few-flowered, 1 to $1\frac{1}{2}^{cm}$ long; scales of male flowers ovate-lanceolate (fig. A), reddish-brown, the midrib pale, not excurrent; scales of female flowers (fig. B) broadly obovate, minutely pointed from the excurrent midrib, reddish-brown with narrow membranaceous, hyaline margins; female flowers three or four; utriculus membranaceous (fig. E), obovoid, obtusely triangular in cross-section, with a distinct obliquely cut beak, ciliate above, at maturity longer than the scale; nerves two, not distinct; caryopsis obovate, sharply triangular in cross-section; rhacheola none; stigmas three.

Habitat: Mountains near Pagosa Peak, southern Colorado, in extensive turf-like patches on bald tops, at 12,000 feet (C. F. Baker). Very abundant on dry rocks at 12,000 feet: Mt. Kelso and Mt. Elbert, middle Colorado (the author).

Differs from *C. filifolia* Nutt., especially in its dark, reddish-brown scales, which are narrower, and by the utricle, which is relatively longer, attenuated at both ends and glabrous excepting the ciliate apex. Boott's *C. Lyoni* is distinct from this by its creeping rhizome, broader leaves and linear-lanceolate, bidentate utricle. *Carex affinis* R. Br., which does not seem to be well understood, has been referred to *C. filifolia* by Boott, but later on to *C. obtusata* Liljebl. by the same author. Professor Bailey has, also, referred it to *C. obtusata.**

Carex oreocharis Holm (fig. 2).

(*C. filifolia* Nutt. var. *valida Olney*, not *C. valida* Nees.)

Rhizome cespitose, culm from 10 to 20^{cm} high, stiff, somewhat robust, terete, sulculate, glabrous; leaves shorter than the culm, 5 to 10^{cm} long, narrowly conduplicate, scabrous along the margins; leaf-sheaths dark-brown, almost black, persisting, slightly fibrillose; spike one, androgynous; male portion many-flowered, clavate, 1 to $1\frac{1}{2}^{cm}$ long, whitish and shining; scales oblong-lanceolate (fig. C), the midrib not excurrent; pistillate flowers 3 to 7; scales (fig. D) ovate-acuminate sharply pointed, the lowest one leaf-like with a distinct awn from the excurrent midrib; utriculus membranaceous, broadly elliptic (fig. F), obtusely triangular in cross-section, with a short beak, minutely pubescent, two-nerved, but the nerves not distinct; at maturity the utricle is longer than the scale, excepting the lower one; caryopsis nearly globular, obtusely angled; rhacheola distinct as in *C. filifolia*; stigmas three.

* Bailey, L. H.: Studies of the types of various species of the genus *Carex*. (Mem. Torr. Bot. Club, vol. i.)

Habitat: Near Denver, Colorado (E. L. Greene). Common on dry rocks in the Aspen-zone at Long's Peak, middle Colorado, at 8,600 feet (the author).

Differs from *C. filifolia* by its broader leaves, and more robust culm, but especially by the pointed scales and the pubescence of the utricle.

These morphological characters may be supplemented by some others, derived from the internal structure of these species together with *C. filifolia* Nutt., in order to draw the specific distinction still more completely. The anatomical structure is as follows:

The root.

Inside the epidermis, which shows the usual structure, is a hypoderm of a single stratum large, thin-walled cells in *C. filifolia*, or of thick-walled in *C. oreocharis*, or finally of three to four thin-walled strata in *C. elynoides*. The cortex is developed as two very distinct zones, of which the outer consists of stereïds, the inner one, on the contrary, of mostly thin-walled parenchyma, which shows the characteristic tangential collapsing, excepting the innermost stratum, which borders on endodermis. The thickness of these two layers seems to vary in these species, and we notice for instance in *C. filifolia* that the stereomatic portion consists of nine strata, while there are only four in the two other species. Moreover, in *C. filifolia* the outer cortex is interspersed with rays of thin-walled parenchyma, which do not show any signs of collapsing. The inner cortex is thin-walled throughout in *C. elynoides* and *C. filifolia*, but in *C. oreocharis* only the five or six inner strata are thin-walled, the outermost four or five being distinctly thickened, but not, however, to such an extent as the stereomatic part of the cortex. The endodermis is thick-walled in *Carex filifolia* and *C. elynoides*, but not so in *C. oreocharis*. By examining the pericambium we find this as only one stratum in all three species, thin-walled in *C. elynoides* and *C. filifolia*, but thickened in *C. oreocharis*. This tissue, the pericambium, is in *C. elynoides* interrupted by all the proto-hadrome vessels, but not so in the two other species; in one root of *C. filifolia*, for instance, six proto-hadrome vessels out of twenty-one had not broken through the pericambium, while in some thinner roots only one of these vessels out of sixteen bordered on endodermis. The leptome and the proto-leptome is very well developed in these species and arranged in alternation with the proto-hadrome. Some large vessels surround the innermost part of the central-cylinder, which is occupied by conjunctive tissue, especially thick-walled in *C. elynoides* and *C. filifolia*. In passing to examine

The stem,

this is terete and hollow in all three species, sulculate in *C. elynoides* and *C. filifolia*, smooth in *C. oreocharis;* a few curved prickle-like projections are observable in *C. filifolia*, but in the two other species the culm is glabrous. The cuticle is smooth and very distinct. Epidermis thick-walled, excepting those cells which contain the silicious cones, and which are observable outside the stereome. The stomata are level with the surrounding epidermis, and are not protected by any papillæ, nor are the subsidiary cells raised above the guard-cells themselves. In the sulculate stems the stomata are, furthermore, equally distributed outside the cortex, without being confined to the bottom of the furrows, or along the sides of them. The cortex consists of palisades, radiating towards the center of the stem and shows wide lacunes in *C. elynoides* and *C. oreocharis;* in *C. filifolia*, on the other hand, the palisade-tissue is very compact and persisting. The stereome is very thick-walled in *C. oreocharis*, but not so in the other species; it occurs as hypodermal groups accompanying the large mestome-bundles, besides that it also covers the hadrome-side of these, bordering on the pith; the smaller mestome-bundles have but very little stereome on either face, separated from epidermis by the palisade-tissue. All the mestome-bundles lie in one peripheral band, larger alternating with smaller ones; they are surrounded by a green, thin-walled parenchyma-sheath, inside of which we find the usual mestome-sheath, which is heavily thickened in *C. oreocharis*, less so in the other species. Some few strata of thick-walled mestome-parenchyma were observed between the leptome and hadrome at least in the larger bundles of all these species. The pith consists of a very thin-walled parenchyma which breaks down, leaving a wide cavity in the center of the stem. In comparing this stem-structure with that of the other *Cyperaceæ* in general, our species seem well characterized by possessing a terete and hollow stem, instead of a triangular and solid one as in the majority of the other species, at least in *Carex*.

The leaf

offers excellent characters by which these species may be readily distinguished from each other, and we find in *C. elynoides* exactly the same leaf structure as we have observed in *Elyna spicata*. The broadest leaf is possessed by *C. oreocharis* from an elevation of 8,600 feet, and the narrowest by *C. elynoides* from the high alpine slopes. The width of the leaf of *C. filifolia* from the foothills is intermediate between these two species. The leaf is not flat in any of these species, but

cylindric with a mediane groove in *C. elynoides*, and conduplicate in the others. There are no furrows on the dorsal face of the blade and no papillæ from epidermis protect the stomata; short, but pointed prickle-like projections from epidermis occur along the keel and the leaf-margins, but they are relatively few in number. The cuticle is very distinct, but not very thick, and it is perfectly smooth. Epidermis is thick-walled with the exception of the cone-cells, and viewed superficially we notice quite a considerable difference in the respective length of the cells outside the stereome and the palisade-tissue. In *Carex elynoides* and *C. oreocharis* the cells of epidermis outside the stereome are almost quadrangular with nearly straight radial walls, while they are rectangular with undulate walls in those strata which cover the mesophyll. Similar structure of epidermis is, as we remember, especially characteristic of the *Gramineæ*, in which, however, the short cells show often a stronger silicification than the others, besides they are frequently more or less fusiform in outline. In *C. filifolia* epidermis shows no such modification. Stomata are present on the lower surface outside the mesophyll and near the margins on the upper; they show the same structure as described above for the stem. The upper face of the blade shows an epidermis of larger cells, and one row of true bulliform cells were observed in *C. oreocharis*, just above the midrib; in the two other species the epidermis-cells are uniformly developed, none being bulliform, but we find in these two species a secondary epidermis of small cells, which is especially distinct above the midrib.

The mesophyll is developed in a very different manner in these species. In *C. oreocharis* it shows a distinct palisade-tissue, the cells of which are vertical on the blade; lacunes are to be found between the mestome-bundles, but they are not very wide and do not extend to epidermis. In *C. filifolia* the palisade-tissue is compact and borders on a large colorless tissue, which occupies the upper part of the leaf, and which is broken down into two large lacunes, separated from each other by a narrow layer of green mesophyll above the midrib. In the leaf of *C. elynoides* we find a relatively narrow palisade-tissue on the lower face of which several cells radiate towards the center of the mestome-bundles; the greater part of the upper face is occupied by an enormous mass of colorless tissue, which is partly broken down into a continuous, wide lacune. The stereome is more thick-walled in *C. filifolia* than in the other two species. It occurs as hypodermal groups on both faces of the blade, accompanying the larger mestome-bundles in *C. oreocharis*, while the smaller bundles are only supported by a

few stereome-cells on the leptome- and hadrome-side separated from epidermis by the palisade-tissue. In *C. elynoides* and *C. filifolia* the stereome on the hadrome-side is separated from the upper epidermis by the colorless tissue, even in the largest mestome-bundles. Common to all three species are two marginal, hypodermal groups of stereome on the upper surface of the leaf. The mestome-bundles occur as large and small ones, in regular alternation with each other. There is a thin-walled, green parenchyma-sheath and a mestome-sheath with thickened inner cell-wall in all three species; in *C. filifolia* and *C. oreocharis* there is, moreover, some few strata of thick-walled mestome-parenchyma between the leptome and hadrome, but not in *C. elynoides*. Tannin-reservoirs were not observed.

Utriculus.

The structure shows a thick-walled dorsal epidermis and from one to six strata of colorless parenchyma between this and the ventral epidermis; in *C. filifolia* the dorsal epidermis has developed a number of small, rounded, wart-like protuberances, besides many erect, sharply-pointed prickles, which abound near the apex of utriculus. Similar prickle-like projections are, also, observable in *C. oreocharis*, but they are not so numerous, and no wart-like protuberances were observed. In *C. elynoides* the utricle is almost wholly glabrous. Two mestome-bundles are developed in utriculus and they are supported by stereome, which, furthermore, occurs as isolated, hypodermal groups, about fifteen in each species.

The rhacheola

is very distinct in *C. filifolia* and *C. oreocharis*, and shows a very thick-walled epidermis, a compact cortex and three mestome-bundles near the center, each partly surrounded by groups of stereome. The rhacheola bears many pointed prickles near the apex, but in no case did we find any development of rudimentary leaves or flowers, which is, otherwise, not uncommon in *Carex*, though exceedingly rare in the monostachyous species.

In summarizing the structural characters which we have noticed in these three species of *Carex*, it seems as if these are very distinct anatomically, notwithstanding the fact that they are all inhabitants of a dry soil, though at different elevation. Among the most prominent characteristics may be recalled the constant interruption of the pericambium by the proto-hadrome in *C. elynoides*, while in the other species some of these vessels are separated from the endodermis; the large colorless, lacunous tissue in the leaves of *C. filifolia* and *C. elynoides* in con-

trast to *C. oreocharis*, where the lacunes are much narrower and located in the palisade-tissue itself; furthermore the well developed bulliform-cells in the latter species, while these are totally absent in the others.

There appears, thus, to be several both morphological and anatomical characters by which these three species may readily be distinguished from each other, and which, moreover, seem to justify the separation of these plants as independent species. It would hardly be natural to consider, for instance, *C. elynoides* as a merely alpine variety of *C. filifolia*, since the latter is often an inhabitant itself of the alpine regions without changing its usual habit to any considerable extent, at least not acquiring any of the peculiarities possessed by the former. As regards *C. oreocharis*, this cannot represent a variety either, inasmuch as it shows relationship to the "*Montanæ*" and may together with *C. scirpoidea* Michx. he counted among the "formæ hebetatæ" of this subsection.

Brookland, D. C., January, 1900.