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A Floridean Red Alga New to Iowa: *Audouinella violacea* (Kütz.) Hamel (Acrochaetiaceae, Rhodophyta)

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DONALD R. ROEDER (Department of Botany and Plant Pathology, Iowa State University, Ames, Iowa 50011). A floridean red alga new to Iowa: *Audouinella violacea* (Kütz.) Hamel (Acrochaetiaceae, Rhodophyta), Proc. Iowa Acad. Sci. 84(4): 139-143, 1977.

Audouinella violacea (Kütz.) Hamel, previously unreported from Iowa, was an important member of the epilithon in the Skunk River in central Iowa from March 1972 through January 1973. During most of the summer it was co-

Red algae, members of the Division Rhodophyta, are scarcely known from Iowa. Buchanan's 1907 review of the literature on Iowa algae inferred that representatives probably occur in the state, but had not been collected. Prescott (1931) later reported only one red alga, *Porphyridium cruentum* (Agardh) Näg., collected by R. E. Buchanan in Story County. The only other formal report of a red alga occurring in Iowa was by Gashwiler and Dodd (1961), who found *Asterocystis* sp. growing in Silver Lake fen, Dickinson county. Since then, *Batrachospermum* spp. have been collected in the state by a number of investigators (see Roeder and Peck, 1977). During an extended survey of the algal flora of a portion of the upper Skunk River (Roeder, 1976), I encountered a floridean red alga which at times became a dominant member of the epilithon. This alga, *Audouinella violacea* (Kütz.) Hamel, was previously unreported from Iowa.

METHODS AND MATERIALS

The Skunk River originates in Hamilton County, Iowa, and flows southeast to its confluence with the Mississippi River at Burlington, Iowa. Seven sampling stations were selected within Story County between Story City and Cambridge. Stations 1 through 4 each consisted of alternating rocky riffles and pools. The substrate at stations 6 and 7 was primarily sand and silt. A U.S. Geological Survey concrete dam was sampled at station 5.

Weekly or bi-weekly sampling began in March, 1972 and terminated in January, 1973. Periodic observations were made through 1976. Substrates were scraped for periphyton with a pen knife or scalpel, and microscopic examination of living material was begun within a few hours of collection. Approximately one half of each sample was preserved in Transeau's solution (6:3:1; H₂O:95% ethyl alcohol:commercial formaldehyde). Voucher specimens are deposited in the Iowa State University herbarium. Photographs were taken through a Bausch and Lomb Series R research microscope and a Leitz Ortholux microscope.

DESCRIPTION OF THE PLANT

A. violacea occurred as a small tufted filamentous colony, one to three mm in height, attached directly to rocks (Fig. 1), or occasionally as an epiphyte on *Cladophora glomerata*. Drew (1935) mentioned that at certain times of the year the plant, which she originally referred to as *Chantransia violacea* Kütz., was more frequent as an epiphyte on *Lemanea* than epilithic. It is often richly branched (Figs. 3, 4, 6, 7, 8)

dominant with *Cladophora glomerata* (L.) Kütz. The alga was morphologically similar to the *Chantransia*-stage of *Batrachospermum* found elsewhere in Iowa. However, because mature *Batrachospermum* plants were never encountered in the Skunk River over a five year period, the alga was assumed to be an independent entity.

INDEX DESCRIPTORS: *Audouinella*, *Audouinella violacea*, Rhodophyta, Iowa algae, red algae, *Chantransia*-stage, *Batrachospermum*.

but sometimes practically devoid of ramification (Fig. 5). It usually is described as distinctly violet to bright red in color (Drew, 1935, 1936; Hamel, 1925; Israelson, 1942), but the specimens from the Skunk River were usually grayish green or purplish, as were North Carolina specimens (letter dated 27 March 1973 from Dr. L. A. Whitford, Dept. Botany, North Carolina State University, Raleigh, N.C.). Macroscopically, the colonies appeared dark brown.

Sexual plants were never observed in the Skunk River. Monospore production was observed throughout the year but most profusely in the winter. Monospores were located either singly on the ends of short branches (Fig. 4), or in clusters (Figs. 6, 7).

Branches of some specimens from the Skunk River terminated in long hyaline hairs. Drew (1936) united taxa with or without hyaline hairs indicating that she did not regard their presence as a significant taxonomic character.

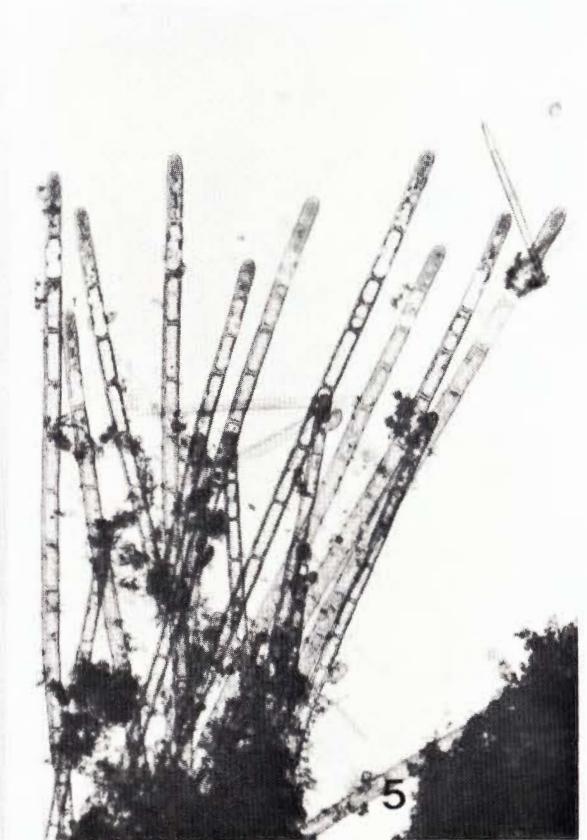
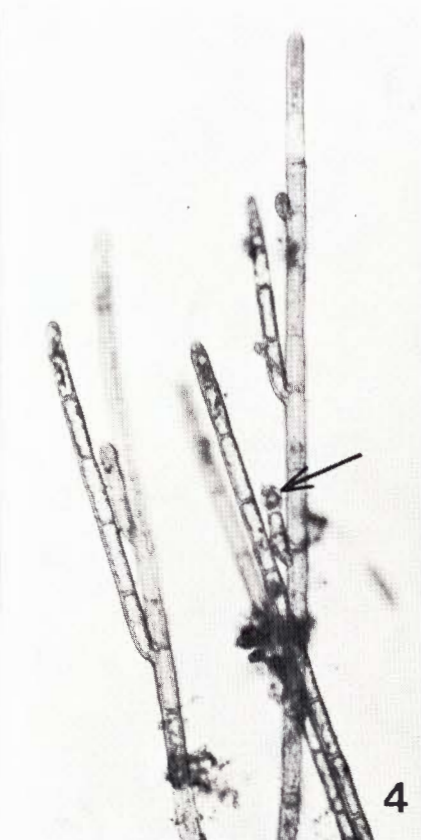
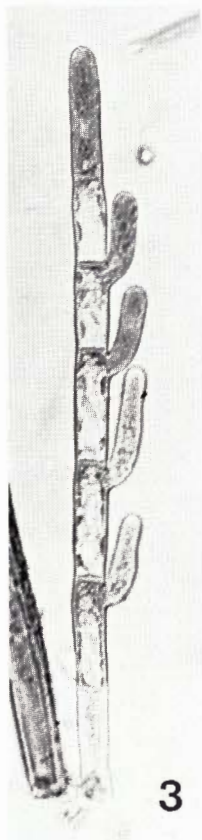
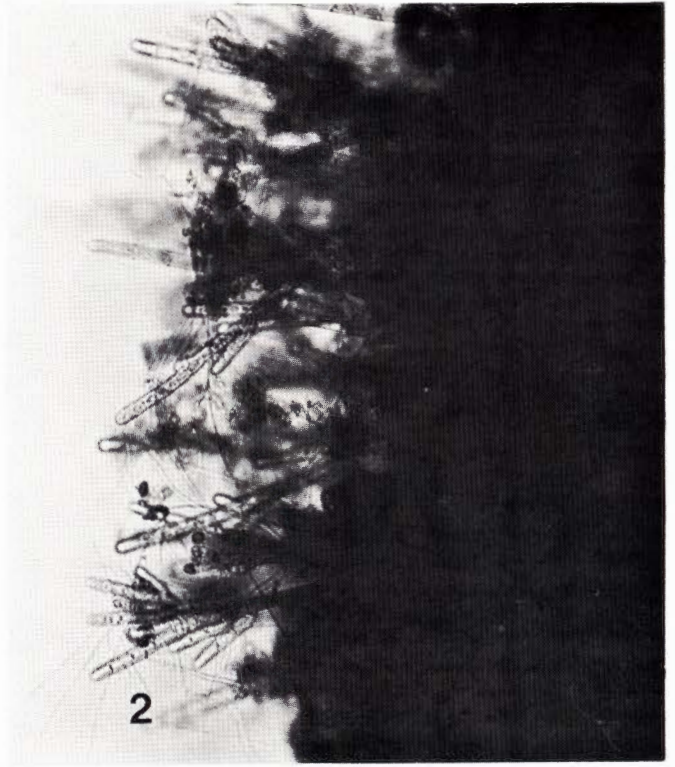
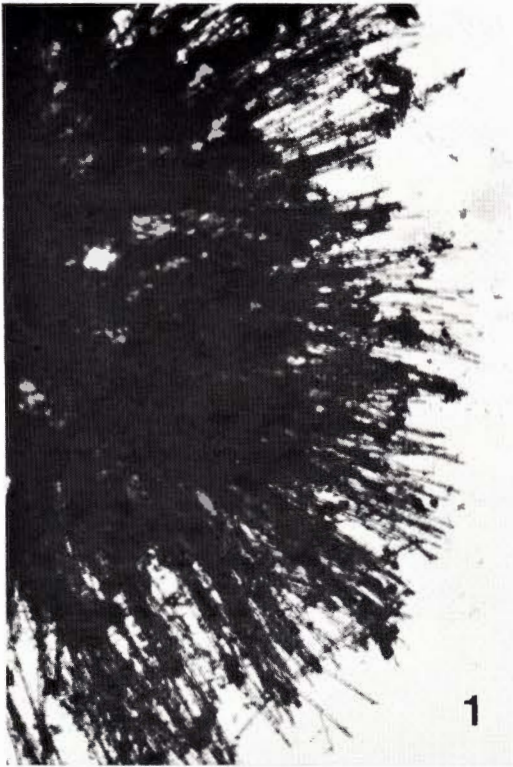
Few of my specimens had spiral chromatophores (Text — Fig. 1b; Figs. 9, 10); the majority of them were discoid or oblong (Text — Fig. 1a, c, d; Fig. 10). Drew (1935) mentioned that the cells of *Rhodochorton violaceum* (Kütz.) Drew (*C. violacea* Kütz.) contained parietal plastids which were usually more dense at the apical end of the cells. She stated, furthermore, that "sometimes the basal end of the plastid is ribbon like, and in other cells the whole plastid is dissected thus and the ribbons are spirally arranged." The same phenomenon was observed in some Skunk River specimens (Text — Fig. 1b, c), although the plastids were much more dissected than in Drew's illustrations.

ECOLOGY

Flint (1970) stated that *Audouinella* is probably the most widely distributed freshwater red alga in North America, but is often overlooked because of its small size. In the Skunk River, the plant grew on rocks from a few centimeters to approximately one half meter in diameter. It was the co-dominant member of the epilithon with *Cladophora glomerata* at stations 3 and 4 during the entire collection period. *Audouinella* was abundant from August 1972 through January 1973 at station 2, but only abundant at station 5 during October. It was never found on sand or silt substrates (stations 1, 6, 7).

A. violacea became the dominant alga in the riffle areas for brief periods following flooding. After periods of heavy rainfall (early August, mid and late September, 1972) *C. glomerata*, which had attained lengths in excess of one meter during low flow conditions in July, was reduced to short, sparsely branched filaments. *A. violacea*, on the other hand, withstood periodic floods probably because its smaller size offered less resistance to scouring by the silt-laden, rapidly flowing water.

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References to *A. violacea* in the literature frequently do not contain ecological information. A notable exception is Dillard (1966) who found that *Audouinella violacea* (Kütz.) Hamel and *Batrachospermum macropsorum* Mont. alternated in relative abundance seasonally in a North Carolina stream. *A. violacea* was dominant only when water temperature was less than 15°C. Reed (1972) stated that *Audouinella violacea* first appeared when the water was "clear, low, and above 10°C." However, monospores were produced abundantly in water temperatures ranging from 14°C to 26°C. She found the plant grew best in shaded environments in rapid current as an epiphyte on *Lemanea*. Flint (1947), also found *Audouinella* sp. in New Hampshire streams throughout the summer, but water temperature data was not presented. *Batrachospermum* was not found in the Skunk River; instead *A. violacea* remained abundant throughout the summer in water temperatures up to 29°C. The reason why the alga was not considered the *Chantransia*-stage of *Batrachospermum* will be discussed later.

TAXONOMY

A. violacea eluded identification for some time, partially because the taxonomy and validity of *Audouinella* and related genera has been variously interpreted. As a result, a number of taxonomic systems exist today. A complete review of this taxonomic problem is beyond the scope of this report, but a brief review of several critical taxonomic treatments is warranted.

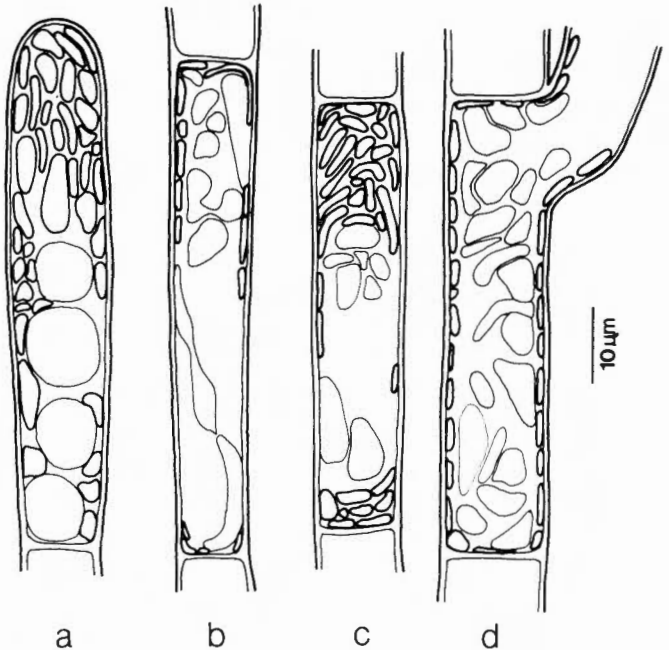
Drew (1928) thoroughly reviewed the taxonomic problems in the *Acrochaetium-Rhodochorton-Audouinella* complex of the Acrochaetiaceae. She united the marine genera *Acrochaetium* Näg. and *Rhodochorton* Näg. to form the emended genus *Rhodochorton* (Näg.) Drew. Additionally, in a later paper (Drew, 1935) she transferred the freshwater alga *Chantransia violacea* Kütz. [*Audouinella violacea* (Kütz.) Hamel] to the emended genus *Rhodochorton* (Näg.) Drew. She showed that it was an independent diplobiontic species with isomorphic tetrasporophyte and gametophyte generations, not just an immature form (*Chantransia*-stage) of another genus, such as *Batrachospermum*.

Papenfuss (1945) also reviewed this complex. He proposed that *Audouinella*, *Rhodochorton*, and *Acrochaetium* be retained as valid genera using chromatophore shape as the distinguishing character. Historically, *Acrochaetium* species have been described as having parietal, stellate, or spiral chromatophores, while *Rhodochorton* species had few irregular to many discoid chromatophores. It was the existence of intermediate types which prompted Drew (1928) to merge the two genera (Papenfuss, 1945).

Fritsch (1945) concluded that there was no basis for separating the freshwater genus *Audouinella* from *Acrochaetium*. He did differentiate between *Acrochaetium* and *Rhodochorton*, however, by chromatophore shape. His descriptions of both stellate and band-shaped chromatophores of *Rhodochorton* are decidedly different from those of Papenfuss (1945).

Feldman (1962) placed the marine genera *Rhodochorton* and *Grania*, and the freshwater genus *Audouinella*, into a new family, the Audouinellaceae, the taxonomic system accepted by Bourrelly (1970). Woelkerling (1971), however, showed that the family name was invalidly published. *Acrochaetium* was left in the Acrochaetiaceae. *Audouinella* and *Grania* both had "ribbon shaped or more or less spirally twisted"

Plate I. *Morphology of Audouinella violacea and the Chantransia-stage of Batrachospermum.* Fig. 1. *A. violacea* habit. X50. Fig. 2. *Chantransia*-stage of *Batrachospermum* collected from Woodman Hollow Creek. X165. Fig. 3. *A. violacea*. Young filament showing characteristic branching pattern. X450. Fig. 4. *A. violacea* monospore (arrow). X200. Fig. 5. *A. violacea*. Young, actively growing filaments. X200.



Text—Figure 1. Line drawings of individual cells of *A. violacea* from one filament. Note the variety of chromatophore shapes and the formation of central vacuoles in 1a.

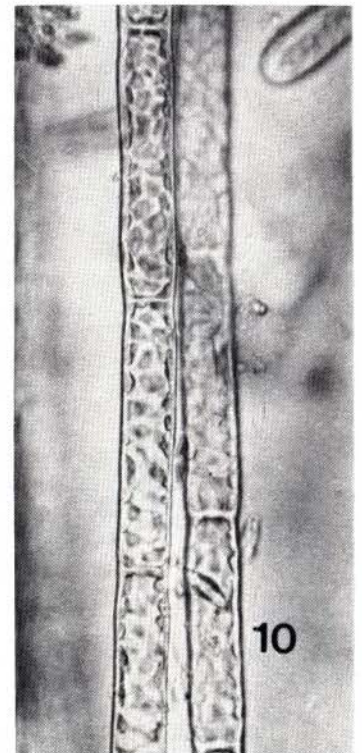
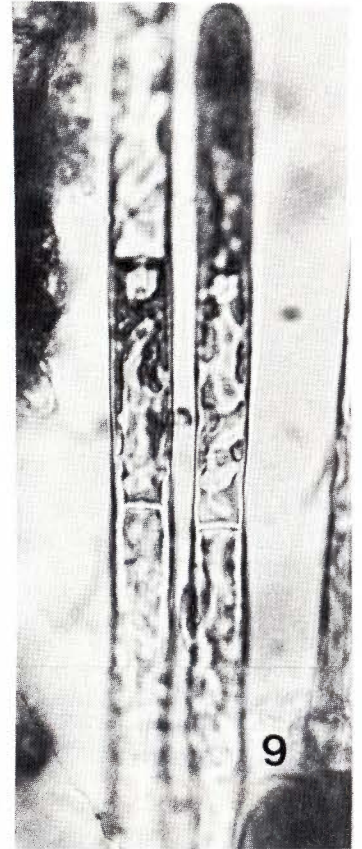
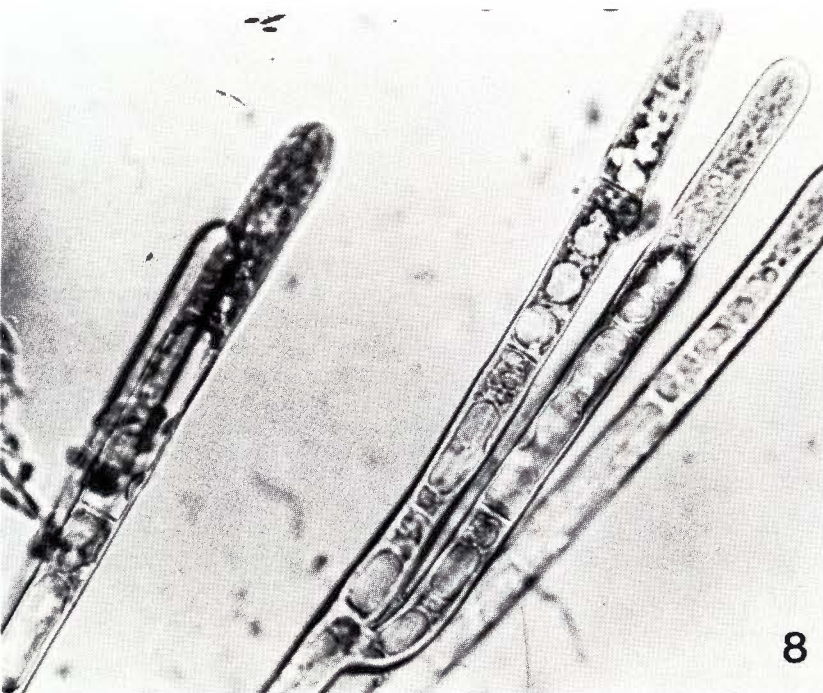
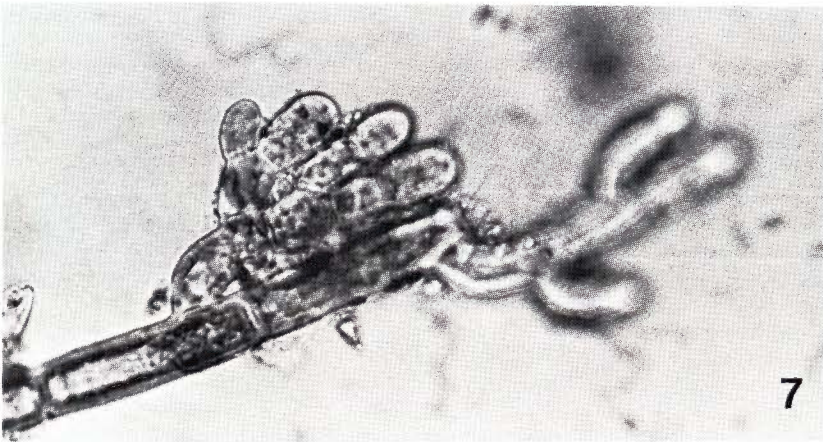
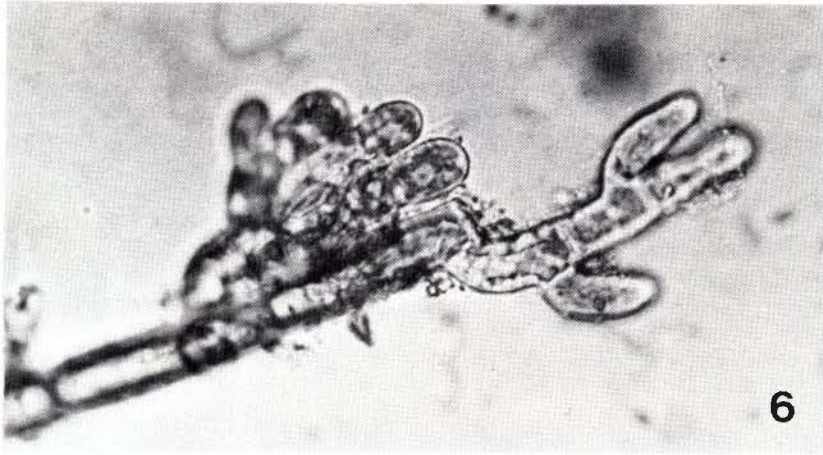
chromatophores, but differed in habitat and carpogonial structure. *Rhodochorton* had disc shaped chromatophores and no known sexual reproduction. Members of the Acrochaetiaceae had only one central or parietal chromatophore.

Hamel (1925), in his monograph of the floridean *Rhodophyceae*, recognized the genus *Audouinella* Bory as the freshwater counterpart of the marine genus *Chantransia*, following the system of Brand (1910). Hamel described this genus (quite differently from Papenfuss and Feldman) as having numerous discoid or oblong chromatophores, numerous monospores, and lacking tetraspores.

Israelson (1942) was the only recent author surveyed who retained the genus *Chantransia*. Most authors have rejected the genus *Chantransia* because the original species described in it were merely immature forms of *Batrachospermum* and *Lemanea* (Drew, 1928; Smith, 1950; Hamel, 1925; Papenfuss, 1945).

Woelkerling's (1971) review of the eleven genera comprising the complex is the most complete to date. He placed species with known sexual life cycles under *Audouinella* Bory (type species: *A. hermanni* (Roth) Duby) and those without under the form-genus *Colaconema* Batters, analogous to the Fungi Imperfecti. Recent chemotaxonomic work by Richardson and Mallery (1973) support the hypothesis that members of the complex are closely related and should be combined. Members of *Rhodochorton*, *Acrochaetium* and seven lesser known genera were thus reassigned to *Audouinella* or *Colaconema*.

A continuing problem in the identification of many floridean red algae is that the immature gametophytes, or *Chantransia* stages, closely resemble *Audouinella*. For example, what appeared to be the juvenile (*Chantransia*) stage of *Batrachospermum* from Woodman Hollow Creek (Fig. 2) (Peck and Roeder, 1977) is morphologically similar to the red alga in the Skunk River. Dillard (1966), who reported both *Audouinella* and *Batrachospermum* in a North Carolina river, stated that *Audouinella* and the *Chantransia*-stage of the latter could be distinguished by the structure of the chromatophore. I was unable to make that distinction.



The cells of both organisms contained mostly discoid or parietal plates, with only occasional spiral ribbon shaped chromatophores. I concluded that the alga in the Skunk River was an independent species because no other red algal genus was encountered over a five year period of observation. The taxon in Woodman Hollow Creek was considered to be the *Chantransia*-stage of *Batrachospermum* because the mature stage of *Batrachospermum* was also present at that site.

In Roeder (1976) I chose not to assign my specimens to *Rhodochorton violaceum* (Kütz.) Drew, primarily because the cells did not usually contain spiral chromatophores as described by Drew (1935). The spiral arrangement of chromatophores was always the exception; I had to view many specimens to find even a single example of this arrangement. Prescott (1962), Hamel (1925), and Whitford (letters dated 20 March 1972, 13 January 1973), however, allowed that discoid or plate-like chromatophores occur in the genus *Audouinella sensu* Hamel. Therefore, I chose to assign the specimens from the Skunk River to *Audouinella violacea* (Kütz.) Hamel. L. A. Whitford (letter dated 20 March 1972) verified my identification. He has been referring all specimens from North Carolina to this species.

Although the specimens from the Skunk River fit Hamel's (1925) description of *A. violacea*, the species identification must remain tentative at this time because of the relatively recent work of Israelson (1942) and Woelkerling (1971). Israelson (1942) placed *R. violaceum* (Kütz.) Drew (*A. violacea* (Kütz.) Hamel) in synonymy with *A. hermanni* (as *Chantransia hermanni* (Roth) Desv.). Woelkerling (1971) stated that "a personal examination of some American material of this taxon strongly supports Israelson's conclusions. . . ." There are, however, notable differences in the features of *A. hermanni* described by Israelson and my specimens. First, sexual stages were never observed in my specimens precluding it from being placed at this time in *Audouinella sensu* Woelkerling. The angle of branching in my specimens was never as great as 45° as described by Israelson for Swedish material. The plants in the Skunk River were never bright red like Israelson's specimens, nor were the chromatophores usually single or spirally arranged ribbons. Whether these morphological differences warrant separation of *A. violacea* (assuming plants in the sexual condition are found) from *A. hermanni* remains to be determined. As Woelkerling stated in reference to species not discussed in his revision: ". . . it seems best not to suggest new nomenclatural combinations until the status of each taxon has been re-examined carefully." Certainly, additional research needs to be done on the taxonomic position of the freshwater counterparts of this complex.

One further possibility remains, however: that this red alga from the Skunk River is merely the *Chantransia*-stage of *Batrachospermum* or of another genus which is unable to develop into the mature, sexual gametophyte in that habitat.

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Plate II. *Morphology of Audouinella violacea*. Fig. 6-7. Two planes of focus showing short branches with a cluster of monospores. X700. Fig. 8. Apical portion of young filament with plastids already segmented in the youngest cells, coinciding with the formation of central vacuoles. X700. Fig. 9. Chromatophore structure in two filaments. X700. Fig. 10. Chromatophore shapes in two filaments. Note the mixture of plate-like and dissected spiral ribbon shaped plastids. X700.