A Preliminary Survey of the Algae of Ellis and Trego Counties Including Methods and Materials Used in Preservation

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A PRELIMINARY SURVEY OF THE ALGAE
OF ELLIS AND TREGO COUNTIES INCLUDING METHODS
AND MATERIALS USED IN PRESERVATION

being

A Thesis Presented to the Graduate Faculty
of Fort Hays Kansas State College in
Partial Fulfillment of the Requirements for
the Degree of Master of Science

by

Ben McFarland, B. S.
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Date July 22, 1959

Approved

Major Professor

Chairman Graduate Council
ABSTRACT

The purpose of this study was to classify and describe some of the algae of Ellis and Trego Counties. There are taxonomic descriptions of 30 species found in the study with 42 photographs of the specimens.

Samples of the algae preserved were placed in the Elam Bartholomew Herbarium, Fort Hays Kansas State College; in the author's own personal herbarium collection and in the herbarium collection of Henry J. McFarland (Assistant Professor of Biology, Fort Hays Kansas State College).

Methods and materials used in the study include a list of photographic equipment and methods, stains used, preservative formula and method used for drying algae on mica slides for the herbarium collection.

A taxonomic list and index to the algae was prepared as well as descriptions and illustrations of the species found. Included with the species descriptions are the list of publications used in identifying them and also a list of where each species has been collected within Ellis and Trego Counties.

According to the general classification used by G. M. Smith, the 30 species described represented 4 divisions, 5 classes, 11 orders, 19 families and 26 genera of algae. However, there were many species that were not described or included in the thesis because of time
limitations, space limitations or failure to identify the species. Further checking of the literature may show that 10 of these species are new for the state of Kansas.
ACKNOWLEDGEMENTS

The writer would like to thank his father, Henry J. McFarland whose knowledge of algae and assistance in identification greatly helped in the preparation of this thesis. The writer would also like to thank Vernie Knudson, a fellow graduate student, who made many of the collections, helped in identification and preservation of specimens. Suggestions made by Mr. Howard Reynolds for the taxonomic descriptions were also of great assistance.

Thanks go to Dr. Tomaneek, chairman of the thesis committee, as well as the other committee members; Dr. Ward Sims, Dr. Harold Chogueill and Dr. Calvin Harbin who read and gave helpful suggestions for the thesis.
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INTRODUCTION

Studies on algae have been very limited in western Kansas. It is difficult to locate literature on algae of this area since there are few formal publications in existence. Most of the literature accumulated was used to build a personal library for this study.

The purpose of this study was to classify and describe some of the algae of Ellis and Trego Counties. There were methods and materials useful to the study and these are included in the thesis. Photography was found particularly useful in keeping a record of the taxonomic study. Descriptions and photographs of most of the specimens collected were placed with the Fort Hays Kansas State College herbarium collection. Specimens were preserved by drying on mica slides or by placing in bottles with a mixture of ethyl alcohol, formaldehyde, glycerin and water. The formula for this mixture is described later.

Research since the Second World War for new sources of food and new medicines has increased interest in algae. Algae have good nutritional values, are found to contain many vitamins and are high in protein. Cultured Chlorella has been found to have fifty per cent protein by dry weight when grown with sufficient nitrogen (Burlew, 1953).

In some protein deficient countries algae are already being tried as part of the human diet. Any study using algae must certainly involve a basic knowledge of classification and use of methods that will help in the identification and study.
There is a need for study of algae as they are one of the links in the food chain of aquatic life, and fish would probably soon disappear without these photosynthetic plants. Many microscopic animals and small fish as well as large animals eat algae directly or indirectly. The great blue whales, for instance, get much of their food by straining out the diatoms and some other algae of the ocean.

More algae could be produced per acre of land than most crops now being produced and without using the earth's valuable soil. It is estimated that twenty tons of algae could be produced per acre per year (Burlew, 1953). Many overcrowded countries perhaps will look to algae as a large source of food. By regulating the nitrogen content of algae growing in an artificial hydrophonic medium the amount of fat and protein produced in the algae can be controlled. With an increased amount of carbon dioxide the growth rate of algae can be greatly increased over what the growth would be under the earth's normal atmospheric conditions. It is believed that the thick layers of diatomaceous earth deposits are of such large size due perhaps to the greater amounts of atmospheric carbon dioxide in past geological eras (Davidson, 1954). Even under present conditions large layers of diatomaceous ooze form in the ocean. The ocean as a farming place for algae supply is only now beginning to be visualized but in such countries as Thailand, ocean algae are already being used to supplement protein deficient diets. In the future, classification of algae will be of great importance in any algae cultivation project. There are some algae poisonous to animals, and other algae yet to be found, may be superior to present algae in growth rate and in
nutritional value. Some pharmaceutical companies in the United States use algae for testing their products as effects can be directly observed in the algae cells that would be difficult to observe in a higher plant or animal.

Kansas algae has been studied extensively only in the eastern half of the state. Thompson (1938) in his publication on the algae of eastern Kansas, reports most of the work that has been done previously in Kansas. Little work has been done in the past on the algae of the western half of the state until the past few years, with the exception of a list of algae compiled in a survey of a small area of Sheridan County. This was listed in a master's thesis by Darland (1935) at Fort Hays Kansas State College. Twenty-eight species were listed in this paper but the preserved specimens collected in that study are no longer in existence for confirmation. Some of these algae were found in the present study. The only other fresh-water collection made in western Kansas was made by McNaught (1920) at Waconda Springs which is located in central Kansas.

Although this thesis deals only with living fresh-water algae, it should be pointed out that Hanna (1932) made a study of some of the diatomaceous marl of Wallace County. This publication would be valuable in making any further studies of this kind.

The zygote is almost a necessity for identification of _Spirogyra_ as well as most of the conjugate algae. Some of the earlier studies in Kansas may be unreliable for this reason. It is largely due to more reliable references with more complete information on each species that allows more accurate identification today. The identification of
the genera *Spirogyra*, *Zygnema* and *Mougeotia* should thus be questioned unless accompanied by a description of the zygotes or reference to materials describing the zygotes. The same thing also applies to a number of the other green algae.
THE GEOGRAPHY OF ELLIS AND TREGO COUNTIES

Trego County is directly west of Ellis County and both are located in north central Kansas. Water drainage in the two counties is into the Smoky Hill River. The Smoky Hill River joins other rivers and in eastern Kansas they unite to form the Kansas River. There are three main streams in Ellis and Trego Counties. They are the Smoky Hill River, the Saline River and Big Creek. All three rivers join east of these two counties.

Collections were made in a variety of habitats including these three principal rivers plus ponds and roadside ditches as well as small tributary streams. Most of the collections were made along the waters edge. Collections were made in nearly all areas of the two counties. A map of each county is included with the herbarium collection listing all the locations where collections were made. These are listed by number and included upon the herbarium labels. In the survey, Ellis County was probably more completely covered than Trego County as the former is the home of Fort Hays Kansas State College and collecting stations were thus closer. However, large numbers of collections were made in each county.
METHODS AND MATERIALS

The importance of recording all observations of algae can not be over emphasized. A variety of methods of study are necessary to get the most out of the time spent in study and classification of algae. There was a time when long hours had to be spent to get drawings of a microscopic object. It often helped if you were a good artist. Drawing specimens still has a place in algology but much time can be saved on many algal specimens by use of photography. Due to the shallow depth of field of microscopic optics, photography has never become too important in the past. There has been improvement in films and cameras which has offset this disadvantage in the last few years. A person has only to look through the biological journals to find extensive use of photomicrography. Drawings can be easily traced from the photographs. It is no longer necessary to be an artist to get good illustrations for publication and identification purposes. However, there are occasionally details in some algae that make it necessary to draw the specimen in a live condition by hand.

Written observations were made at the time the specimens were collected and examined. A form was used to record observations made so that no information was accidentally omitted. A copy of the form used for all the photographs taken is inserted in the appendix of this thesis. No attempt will be made to explain it other than that it was modified from a form listed in a publication (Anonymous, 1952). In addition to photographs, written observations of the algae were tabulated so that
at a later date corrections could be made. Samples of the algae were preserved for verification.

All photographs were taken with one of three cameras. The earlier photographs taken were made with a Kine Exacta on tungsten type Kodachrome 35 mm. film with the aid of a microscope adapter. For the past two years all photographs have been taken with an American Optical type 662C camera with a 35 mm. back or with a Bausch and Lomb 3 1/4 X 4 1/4 model K camera. All the 35 mm. photographs were taken on 36 exposure rolls of Kodachrome tungsten type A Kodachrome Professional film. The color slides from this film were then placed in an enlarger and projected on cut sheet film placed in an easel. A sheet of black paper was placed under the film during the exposure. Black and white prints were then enlarged from this developed negative. These black and white prints made from the Kodachrome give an excellent print with good contrast. High contrast was necessary to get good illustrations. If algae were likely to move during the long exposures the 3 1/4 X 4 1/4 cut sheet film camera was used with fast film. Using a fine grain film was often necessary in order to get maximum enlargement when certain small algae were photographed. A good fine grain developer was used. A paper made for low contrast negatives was found to give the best reproductions and so a "number four paper" was used for all prints.

The exposure meter used in this study was a model 200-M and is manufactured by the Photovolt Corporation. Test exposures had to be made at varying shutter speeds until the best negative or color slide was obtained. A good type illumination such as a Koehler type is
sometimes considered necessary but an ordinary direct illuminating
type desk lamp with a regular tungsten light bulb gave satisfactory
results for black and white film. A photoflood bulb was used for
color. A voltage regulator was not found necessary to get good color
slides and was not used in this study. When making color slides with
artificial light color film, all daylight should be excluded as it will
affect the color temperature.

The advantage of photographing algae in a living condition is that
it will show their true form while after being dried or preserved in
other ways the condition of the cells may be changed. Many details
will show in a photograph that might be accidentally left out of a
drawing. Measurements of the size of algae can also be made directly
on the negatives where the camera always has a fixed distance from the
microscope eyepiece. All of the cameras used in this study had this
fixed distance. A wide field, fifteen-power ocular was used to get
negatives with an image covering the whole area of the negative instead
of a round circle from the ocular image.

Stains must be used to show certain structures in algae. India
ink or an iodine solution was commonly used to show sheaths and gelazi-
tinous substances surrounding the cells or colonies. Gentian violet
was used quite often to show pseudocilia or flagella. Iodine and india
ink were applied by placing one drop on the edge of the cover glass and
this allowed the concentration to vary across the slide. Therefore,
a specimen could usually be found in the proper concentration to show
the structures without distorting the cells.
Iodine or magnesium sulfate solutions were used in stopping the movement of the flagellates and the motile type blue-green algae such as *Anabaena* and *Oscillatoria*. These solutions were also applied on one edge of the cover glass. The diffusion of the solutions are usually slow enough that there is time to get photographs taken before the solution diffuses through the field of view in too high a concentration. Whenever possible photographs were taken without any stains in order to show a natural cell structure. Diatoms were either photographed live or when they were dried on slides. It was sometimes necessary to select specimens that had lost their chloroplasts in order to show detailed markings of the cell walls on desmids and diatoms. The diatoms that were dried on mica or preserved in a liquid preservative can be treated with acid later to bring out the markings and then can be permanently mounted on a slide in a mounting medium.

Many measurements were necessary to identify certain species accurately. A number of individuals of each species were measured in order to get the range of size. All measurements were made with a ten-power ocular with a calibrated micrometer disc inserted in the ocular. It was calibrated against a Bausch and Lomb calibrating slide. The size of each alga was recorded separately because the range of size is sometimes not as important as the most common size. Measurements were taken whenever possible from a number of different collections.

Records of pH and temperature were often made at the time of collection. Wide range pH paper was used. The pH of the collections were recorded on the form previously described and were also listed on the herbarium labels. The accuracy of calibration of the thermo-
meters used was not measured but they were probably accurate enough to show the type of temperature conditions present.

Liquid preserved algae were put in a solution of 10% formalin, 35% water, 50% of 50% ethyl alcohol and 5% glycerine. Most of the algae were dried on sheets of ordinary stove mica that were cut to a size of 1 by 3 inches as described by Drouet and Daily (1956). This is the normal size of a microscope slide and they were used as a microscope slide. They are very thin and easy to store in envelopes. Mica slides are also resistant to breakage and can be mailed for exchange with other herbariums. The algae were spread thin enough over most of the slide so that light would pass through it but thick enough that plenty of specimens were present. They were dried without the addition of heat in a well ventilated place in order to dry as fast as possible. An electric fan was used in drying most of the mica slides. This method was especially good for preserving the blue-green algae and was also useful for diatoms. The algae usually stayed attached to the mica without any aid. A few drops of water were placed on the slide and a cover glass applied and was then allowed to set for a few minutes before using. When use of the slide was completed it was dried out and then stored again in its envelope. The green algae usually lost their shape when dried but sometimes a household detergent solution was used and some of their shape was regained.

All specimens reported in this study have been placed in the Elam Bartholomew Herbarium at Fort Hays Kansas State College,
the author's own personal herbarium and in the collection of Henry J. McFarland (Assistant Professor of Biology, Fort Hays Kansas State College).

Included with the preserved collection of algae was a loose leaf binding of the photographs with descriptions of the species on the back of each page. An index to the species with a list of photomicrographs made of each species, a list of the places it has been collected, the size of each specimen measured and a list of the publications where it is described was also included.
The general classification described by Smith (1950) was used in this study. He divided the algae into seven main divisions, four of which were found in Trego and Ellis Counties as a part of this study. Other divisions are probably present. The four divisions found were Chlorophyta, Euglenophyta, Chrysophyta and Cyanophyta. Pyrrophyta has also been found in the past but no records were kept of it.

Of the filamentous algae found in Ellis and Trego Counties; the genera Spirogyra, Rhizoclonium, Cladophoria, Zygnema, Oedogonium and Vaucheria were most abundant. The diatoms cannot be excluded from the algae as they were very abundant all year and during the winter months were especially noticeable because of the reduction in quantity of the blue-green algae and some of the green algae. A number of species of Spirogyra, Zygnema and Oedogonium are not listed as it is very difficult to find them in the fruiting condition which is necessary for their identification. A number of species seem to vary from the descriptions of the literature and these were also not listed. A number of diatoms are included in this thesis but much work remains to be done on the diatoms of these two counties.

Collections in western Kansas made outside of Ellis and Trego Counties contain about the same species found in this study but some of the species found in only small quantities and listed in this thesis are found in greater quantities elsewhere. One species of Anabaena, for example, is found occasionally in Ellis and Trego Counties but
in one location in southern Hodgeman County it has been collected in large quantities. A species found in a certain location, however, at one time may later disappear to be replaced by other species. With all the farm ponds that have been built during the past years, suitable habitats for more algae will increase.

Index to Species

Division: Chlorophyta

Class: Chlorophyceae

Order: Tetrasporales

Family: Palmellaceae

Gloeocyctis gigas (Kutz.) Lagerheim, p. 16

Family: Tetrasporaceae

Tetraspora gelatinosa (Vauch.) Desvaux, p. 17

Order: Ulotrichales

Suborder: Ulotrichineae

Family: Chaetophoraceae

Draparnaldia glomerata (Vauch.) Agardh, p. 19

Order: Cladophorales

Family: Cladophoraceae

Cladophora glomerata (L.) Kutzing, p. 21
Rhizoclonium hieroglyphicum (Ag.) Kuetzing, p. 23

Order: Chlorococcales

Family: Micratiinaeae

Micractinium pusillum Fresenius, p. 25

Family: Hydrodictyaceae

Hydrodictyon reticulatum (L.) Lagerheim, p. 29

Family: Scenedesmaceae

Scenedesmus opoliensis P. Richter, p. 31

Order: Zygcmatales

Family: Desmidiaeae

Closterium moniliferum (Bory) Ehrenb., p. 29
Cosmarium granatum Breb., p. 30
Cosmarium vexatum?, p. 32
Cosmarium reniforme (Rafis) Archer, p. 35

Division: Euglenophyta

Class: Euglenophyceae

Order: Euglenales

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Division: Chrysophyta
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Class: Bacillariophyceae
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        Oscillatoria tenuis Agardh, p. 58
        Spirulina major Kuetzing, p. 60
    Suborder: Nostocaceae
      Family: Nostocaceae
        Aphanizomenon flos-aquae (L) Ralfs, p. 61
        Anabaena flos-aquae (Lyngbye) Brebisson, p. 64
Description of Species

The following algal descriptions are taxonomic accounts of the algae found. The references listed just below the scientific name were those used in identifying the species. Some of the publications contained both keys and descriptions, or they contained only one of the two. Publications referring to the algae being found in Kansas may in some cases be only a listed scientific name without descriptions. If the references contained figures of the species they were listed with the references.

All measurements given were made by the author in the study. In some cases, if not very many specimens were available or were not measured in quantity, the measurement figures may not give a complete range of physical size. If this study disagreed on the size of a certain species in comparison with the references it was indicated in the description.

At the end of the descriptions are listed some of the places the species were found within Ellis and Trego Counties. In some cases this is not a complete list but one or several collecting points are given for each county.

Photographs are presented at the end of each species description. In some cases several photographs were necessary in order to show all physical structures or to show top, side or end views.
Gloecystis gigas (Kutz.) Lagerheim

Collins 1909:309.
Prescott 1951:84, pl. 3, fig. 16.
Tiffany and Britton 1952-21, pl. 3, fig. 24.
West and Fritsch 1927:90, fig. 18F-H.

Cells spherical or ovoid, 10.3-13.5 microns diameter; a single cell or colonies up to 8 celled enclosed in a lamellate, gelatinous envelope; cells green but sometimes brownish-green because of oil globules; attached to other algae or to submerged objects.

(1) Small stream, Trego County, 1/2 mile below Cedar Bluff Dam at first bridge on south side of the Smoky Hill River, growing with Spriogyra, 3-1-59.

Fig. 1. Gloecystis gigas
**Tetraspora gelatinosa** (Vauch.) Desvaux

Collins 1909:139.
Prescott 1951:88, pl. 5, figs. 3-4.
*Thompson 1938:21, pl. 4, fig. 3.
Tiffany and Britton 1952:22, pl. 4, fig. 33.
West and Fritsch 1927:93, fig. 21A-C.

Cells globular, usually 7.9-10.4 microns in diameter, arranged in the form of a cylindrical sac at first attached and later free floating; air bubbles in the sac keep it afloat, sac commonly lobed and held together by a mucilage-like substance; cells in groups of 2 or 4 usually; pseudocilia do not show unless stained; pseudocilia length many times the cell diameter with those measured up to 152 microns in length; they apparently do not function in locomotion.

(1) Big Creek, Ellis County, at first bend in river west of Hays south bridge, under the ice, 2-11-59.

(2) Small stream, Ellis County, 3 miles west and 2/10 of a mile south of Yocemento at a bridge, 2-22-59.

(3) Small stream, Trego County, 8/10 of a mile below Cedar Bluff Dam at first bridge on south side of river, 4-22-59.

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*This symbol used throughout the descriptions in this thesis to indicate citations that the species has previously been found in Kansas.*
Fig. 2. *Tetraspora gelatinosa*, unstained

Fig. 3. *Tetraspora gelatinosa*, stained with gentian violet, showing pseudocilia
Draparnaldia glomerata (Vauch.) Agardh

Collins 1909:303-304.
*McNaught 1920:164, pl. 4, fig. 27.
Prescott 1951:120, pl. 15, fig. 5.
Tiffany and Britton 1952:38, pl. 11, fig. 80.
West and Fritsch 1927:187, fig. 70A.
Wolle 1887:108, pl. 92, fig. 1.
Wood 1872+207.

Cells of main stem decidedly barrel-shaped, nearly colorless except for a light green transversely zonate chloroplast in each cell, cells 27.6-62.1 microns in diameter in the prostrate portion of the plant, cell length about 23.0-179.0 microns; erect branches repeatedly branched and spreading, ending in pointed setiferous cells; branches opposite or whorled fascicles, set at right angles to the main axis in many instances; branches elliptical to broadly orbicular in shape; difficult to separate from Draparnaldia plumosa and can be done only by the fact that D. glomerata has the fascicle of branches more oval or obtuse while D. plumosa has the fascicle branches lanceolate in outline; D. glomerata does not have the distinct main branch axis that D. plumosa has; collected only in one place during the study and in small quantities; more collections should show cell size to range larger than the figures given; in the prostrate portion they were only 27.6-62.1 microns in diameter while Prescott (1951) lists them as 50.0-100.0 microns in diameter; those cells measured were probably on immature plants.
(1) A small stream, Trego County, 8/10 of a mile below the Cedar Bluff Dam, south side of the Smoky Hill River at a bridge, 2-22-59.

Fig. 4. *Draparnaldia glomerata*
**Cladophora glomerata** (L.) Kutzing

Hylander 1928:139.
*Mannconi 1932:187, pl. 2, fig. 48.*
*McNaught 1920:165, pl. 4, fig. 29.*
Prescott 1951:138, pl. 20, figs. 8-9; pl. 21, figs. 1-2.
*Thompson 1938:26-27, pl. 5, fig. 7.*
Tiffany and Britton 1952:45, pl. 13, fig. 93.
West and Fritsch 1927:170, fig. 64.

A very common Kansas alga that forms dark green masses attached to rocks, stones and sticks; thalli many macroscopic branches at upper end; cells of main axis 45.0-150.0 microns diameter and length six to seven times the diameter; multinucleate with numerous pyrenoids; should be compared with *Rhizoclonium hieroglyphicum* which seldom has branches; has been collected in nearly all areas of Ellis and Trego Counties as well as many other western Kansas counties.

(1) Big Creek, Ellis County, Custer Island, 6-9-58, usually present.

(2) Small stream, Ellis County, 2 miles north of Hays on U. S. 40 at bridge, 6-9-58.

(3) Smoky Hill River, Ellis County, Antonino Bridge, 10-3-58, usually present.

(4) Spring Creek, Trego County, 1 1/10 miles west of east county line at bridge on U. S. 40, 1-14-59.

(5) Small stream, Trego County, first bridge east of Cedar Bluff Dam about 9/10 of a mile below the dam, 1-22-59.
Fig. 5. Cladophora glomerata
Rhizoclonium hieroglyphicum (C. A. Ag.) Kuetzing

Prescott 1951:142, pl. 23, fig. 3.
*TThompson 1938:27.
Tiffany and Britton 1952:46, pl. 13, fig. 91.
West and Fritsch 1927:168, fig. 63.

Cells 27.5-41.3 microns wide by 92.8-430.0 microns long, cells often longer than listed in the literature; filaments long, wiry, unbranched except for rare short branches usually a single cell in length; chloroplasts vary with age of the plant from very dense to open reticulate; green or sometimes yellow green in color; found commonly in western Kansas in standing and slowly moving water; cells have numerous starch-containing pyrenoids; a very hardy variety and easy to culture or grow in an aquarium.

(1) Big Creek, Ellis County, Custer Island spillway, southeast of Hays water 68 degrees F., pH 6, 9-17-58.

(2) Smoky Hill River, Ellis County, Antonino bridge, 10-3-58.
Fig. 6. *Rhizoclonium hieroglyphicum*
**Micractinium pusillum** Fresenius

Prescott 1951:287, pl. 66, fig. 8.
Smith 1950:235, fig. 147.
*Thompson 1938:38, pl. 8, fig. 24.
Tiffany and Britton 1952:106, pl. 33, fig. 329.
West and Fritsch 1927:122, fig. 34A.

Colony free floating; 4-64 spherical cells usually quadrately or tetrahedrically arranged, with up to 7 setae on the free wall of cell; cells 6.9-7.0 microns diameter, usually forming 4-celled coenobia that join to form larger multiple coenobia; chloroplast a parietal cup with one pyrenoid; setae up to 44.7 microns or possibly more.

(1) Smoky Hill River, Trego County, 10-3-58.

(2) Picken Pools, Fort Hays Kansas State College campus; Ellis County through summer of 1958.
Hydrodictyon reticulatum (L.) Lagerheim

Collins 1909:176, pl. 6, fig. 62.
*Mannoni 1932:187, pl. 2, fig. 33.
Prescott 1951:219-220, pl. 47, fig. 1.
*Thompson 1938:32.
Tiffany and Britton 1952:110, pl. 29, fig. 289.

Cells macroscopic, elongate-cylindric, branched to form a saccate, reticulate coenobium; cells variable in size, up to 200.0 microns in diameter or more and a centimeter or more long, form a 3-6 sided mesh, young cells are very small and have few pyrenoids and little cell color, older cells much larger and have many pyrenoids with a green cell color; grows very fast under favorable conditions and usually clogs a small stream or pond after a short time.

(1) A small stream, Ellis County, 1/2 mile south of Yocemento, 6-5-58.
(2) Big Creek, Ellis County, 3 miles west and 1/8 mile north of Yocemento, 1950.
Fig. 8. *Hydrodictyon reticulatum*
Scenedesmus opoliensis P. Richter

Prescott 1951:279, pl. 63, fig. 18.
Tiffany and Britton 1952:122, pl. 35, fig. 355.

Colony with 2, 4, or 8 cells of a naviculoid shape, arranged in a single series; inner cells 18.9 by 6.9 microns; cells are in contact along 1/3 the length of their lateral walls, terminal cells with one spine on each pole, inner cells usually with no spines; free faces of the outer cells convex or sometimes straight.

(1) Big Creek, Ellis County, Custer Island, southeast of Hays, 1952.

Fig. 9. Scenedesmus opoliensis
Closterium moniliferum (Bory) Ehrenberg

Irenee-marie 1939:66, pl. 5, figs. 1-2.
Taft 1931:282, pl. 1, fig. 3.
Tiffany and Britton 1952:172-173, pl. 52, fig. 549.
West and West 1904-1911. 1:142, pl 15, figs. 15-16.
Wolle 1892:48-49, pl. 8, fig. 15.
Wood 1872:113-114.

Cells 35.4-45.0 microns wide at isthmus by 270.0-345.0 microns long, moderately curved with inner margin slightly inflated, outer margin about 100 degrees of an arc or slightly more in curvature, walls smooth and colorless, 6-7 median pyrenoids in each semicell, terminal vacuoles conspicuous; a common species in Ellis and Trego Counties.

(1) Smoky Hill River, Ellis County, Antonino bridge, 10-3-58.

(2) Big Creek, Ellis County, Custer Island, southeast of Hays, pH 5.9, water 42 degrees F., 11-21-58.

Fig. 10. Closterium moniliferum
Cosmarium granatum Breb.

Hylander 1928:84, pl. 13, fig. 15.
Irenée-marie 1939:167, pl. 23, fig. 13.
Taft 1931:296, pl. 2, fig. 10.
*Thompson 1938:43, pl. 10, fig. 2.
Tiffany and Britton 1952:186-187, pl. 53, fig. 565.
Wolle 1892-1896, pl. 61, fig. 13; pl. 18, figs. 14-15.

Cells 20.7-25.9 microns wide and 31.0-39.7 microns long, about 17.0 microns thick, isthmus 4.5-10.4 microns; cells 1 1/6 to 1 1/2 times longer than broad; sinus deeply constricted, linear, slightly dilated at the apex; semicells truncate-pyramidate, converging toward the apex, rounded basal angles, sides at base nearly parallel; sides convex, straight or slightly concave; chloroplast axial, a pyrenoid in each; vertical view elliptic, lateral view of semicells elliptic-ovate; walls smooth, finely punctate.

(1) Small pond, Trego County, 3 miles east of Cedar Bluff Dam, 9-21-58.
Fig. 11. Cosmarium granatum, front view

Fig. 12. Cosmarium granatum, lateral view
Cosmarium vexatum?

Prescott 1931:127.
Taft 1931:298, pl. 2, fig. 4
West and West 1904-1911. 3:187, pl. 92, fig. 4.

Cells when small slightly longer than broad, those larger are up to about 1 1/3 times longer than broad, deeply constricted, sinuses are narrow linear; apex truncate, often dilated, retuse, sometimes slightly undulate or straight, or slightly concave; sides of short cells convex, longer cells slightly concave in end 1/3 of semicell and convex in other 2/3 of the semicell (See fig. 14), sides usually with 5-6 undulations; vertical view oblong-elliptic with central inflations on either side; chloroplasts axial with two pyrenoids; cells 20.7-58.7 microns broad by 20.7-79.4 microns long, isthmus 3.5-20.7 microns broad; 13.8-20.4 microns thick.

(1) Smoky Hill River, Ellis County, Anthony bridge, 10-3-58.

(2) A small pond, Trego County, 3 miles east of Cedar Bluff Dam on south side of road, 9-21-58.
Fig. 13. *Cosmarium vexatum?* Front view, normal cell

Fig. 14. *Cosmarium vexatum?* Front view, nearly vacant cell, showing punctae
Fig. 15. Cosmarium vexatum? Vertical view, showing central inflations

Fig. 16. Cosmarium vexatum? Vertical view, showing punctae
Cosmarium reniforme (Ralfs) Archer

Hylander 1928:86, pl. 12, fig. 12.
Taft 1931:298, pl. 2, fig. 14.
Thompson 1938:42, pl. 9, fig. 16
Tiffany and Britton 1952:188, pl. 53, fig. 586.

Cells 22.4-47.4 microns broad by 47.4-56.1 microns long, about 24.1 microns thick, isthmus about 13.8-14.7 microns wide, length greater than the breadth; deeply constricted with sinus narrow and closed but widely dilated, sinus pore distinctly visible; semicells reniform, outline granulate; vertical view elliptic, lateral view semicells circular; chromatophores axial with 2 pyrenoids in each semicell.

(1) Smoky Hill River, Ellis County, Antonino bridge, 10-3-58.

Fig. 17. Cosmarium reniforme
Phacus longicauda (Ehrenb.) Dumardin

Prescott 1951:400, pl. 87, fig. 1.
*Thompson 1938:53, pl. 11, fig. 11.
Tiffany and Britton 1952:323, pl. 88, fig. 1022.

Cells ovoid with a long tapering caudus: 45.0–70.0 microns in diameter and 85–145 microns long, longitudinally striated; flagellum shorter than body length; there is one large disc or ring shaped paramylum body, several smaller ones are also often present.

(1) Big Creek, Ellis County, Custer Island, southeast of Hays, 1950, exact date not known.

Fig. 18. Phacus longicauda
**Phacus acuminata Stokes**

Prescott 1951:396, pl. 88, fig. 4.
*Thompson 1938:54, pl. 11, fig. 14.
Tiffany and Britton 1952:323, pl. 88, fig. 1024.

Cell usually ovoid, with a short flagellum, greatest width posteriorly to the middle region, about 20.7 microns wide; body length 31.0 microns, overall length 39.9 microns; dorsal furrow extending 12.0 microns approximately; longitudinally striated periplast; one large paramylum body, a ring like disc, one smaller paramylum body commonly near the spine base, those found had the second smaller body present.

(1) Smoky Hill River, Ellis County, Yocemento bridge, 1-4-59.

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Fig. 19 Phacus acuminata
**Tribonema bombycinum** (C.A. Ag.) Derbes and Solier

Prescott 1951:367, pl. 96, fig. 10.
*Thompson 1938:16, pl. 2, fig. 19.
Tiffany and Britton 1952:210, pl. 57, fig. 648.

Cells usually barrel-shaped, sometimes cylindrical, 6.8-11.5 microns in diameter, 10.4-21.0 microns long, made up of "H" pieces; numerous chromatophores; pale yellow-green filaments unbranched with thin cell walls, sometimes slightly constricted at the cross walls.

(1) Big Creek, Ellis County, Custer Island, southeast of Hays, water 1 degree C., 1-25-59.

Fig. 20. Tribonema bombycinum
*Bumilleria sicula* Borzi

Prescott 1951:366, pl. 96, fig. 6.
Prescott 1954:132, fig. 213

Filaments 12.0-20.7 microns in diameter; cell length 1 1/5 to 1 2/5 times filament diameter; filaments short, often broken on the ends showing the "H" shaped pieces of the cells; filaments unbranched; differs from *Tribonema bombycinum* because of larger diameter, lacking barrel-shaped cells but having straight cell walls and a darker more brownish color; the "H" pieces usually visible while in *T. bombycinum* usually not visible; 2-4 chromatophores in each cylindrical cell.

(1) Big Creek, Ellis County, Custer Island Bridge, southeast of Hays, water 42 degrees F., pH 5.9, 11-21-58.

(2) Spring Creek, Trego County, 1 1/10 miles west of east county line on U.S. 40, 1-14-59.
Fig. 21. *Bumilleria sicula*

Fig. 22. *Bumilleria sicula*, broken cell showing "H" piece


**Vaucheria sessilis** (Vauch.) De Candolle

Collins 1909:425.
*Mannoni* 1932:187, pl. 2, fig. 50.
Prescott 1951:294 pl. 68, fig. 5.
*Thompson* 1938:39, pl. 9, fig. 2.
Tiffany and Britton 1952:213, pl. 36, fig. 378.

Filaments usually 51.7-72.4 microns in diameter, unbranched or sometimes branched, lacks cross walls in the vegetative filaments; usually green to yellow-green in color; monoecious; one or two oogonia, commonly with two that are paired, one on each side of the antheridia, or a single oogonia also next to the antheridia; on a short pedicel, usually hooked or circinate; a common species.

(1) Big Creek, Ellis County, 3 miles west and 1/8 mile north of Yocemento at bridge, 4-4-59.
Fig. 23. *Vaucheria sessilis*, with two oogonia

Fig. 24. *Vaucheria sessilis*, with one oogonia
Diatoma vulgare Bory

Elmore 1921:50, pl. 22, figs. 813-814.
Smith 1933:233, fig. 154C.
Tiffany and Britton 1952:230, pl. 61, figs. 686-687.
West and Fritsch 1927:365.
Wolle 1890, pl. 46, figs. 12-14.

Girdle view 13.8-17.3 microns wide and 53.5 microns long, valve view 10.4 wide, cells form zigzag colonies but occur singly also; common through Ellis and Trego Counties, usually intermixed with other algae; cells rounded on corners and with delicate intercalary bands in girdle view; valve lanceolate to almost elliptical and narrowed toward the rounded poles, 14-16 transverse striations in 10 microns, 5-7 ribs in 10 microns and very fine indistinct pseudoraphe.

(1) Smoky Hill River, Trego County, 1/2 mile below Cedar Bluff Dam, 11-9-58.
Fig. 25. *Diatoma Vulgare*, girdle view

Fig. 26. *Diatoma vulgare*, valve view
Fragilaria capucina Desmaüieres
Elmore 1921:51, pl. 2, figs. 68-72.
Tiffany and Britton 1952:234, pl. 62, fig. 698.
West and Fritsch 1927:365, fig. 152C-D.

Cells usually united laterally throughout the length of cells to form long chains; cells measure 1.2-6.6 by 11.6-40.4 microns in normal girdle view, which shows the cells as linear rectangles; valve view with frustules rostrate at poles; chromatophores together with inclusions form a pattern consisting of a double row of dots down each side of the filament about 1/4 to 1/3 the length of the cells in from the poles of the cells; from the marginal beads or dots striations extend across the cell making 14-15 in 10.0 microns.

(1) Cedar Bluff Reservoir, Trego County, 11-9-58.

(2) Spring Creek, Trego County, 1.1 miles west of east county line on U.S. 40, 1-14-59.
Fig. 27. *Fragilaria capucina*, girdle view
Synedra ulna (Nitzsch) Ehrenberg

*Curtis 1901:70, 78.
Elmore 1921:55, pl. 3 figs. 116-130; pl. 4, figs. 131-139.
Tiffany and Britton 1952:237, pl. 63, fig. 713.

Cells in valve view 3.4-6.9 microns broad, in girdle view slightly widened in the extremities but in the valve view the cell narrows toward the poles with the poles rounded; pseudoraphe narrowly linear, sometimes absent in the central region of the cell; 8-7 striations in 10 microns on those checked; a variable species with a number of varieties; common in most collections of algae.

(1) Smoky Hill River, Trego County, 11-9-58.
(2) Small stream, Ellis County, 5/10 of a mile north and 1 1/10 miles east from the Yocemento bridge on a small stream, 1-7-58.
Fig. 28. *Synedra ulna*, girdle view

Fig. 29. *Synedra ulna*, valve view
*Pinnularia viridis* (Nitzsch) Ehrenberg

*Navicula viridis* (Nitzsch) Kuetzing


Cells in valve view about 15.0-25.0 microns wide by 80.0-100.0 microns long, however varies greatly in size from this figure; girdle width is a little more than valve width; very noticeable in western Kansas because of its golden-brown color nearly filling the cell in girdle view; very common in many collections; valves usually linear-elliptic, sides without a central inflation but usually slightly convex, raphe slightly undulate; two plate-like chromatophores visible in valve view; one central module and two prominent polar nodules; costae are heavy with about 6-7 in 10.0 microns.

Common is most areas of Ellis and Trego Counties.
Fig. 30. *Pinnularia viridis*, girdle view

Fig. 31. *Pinnularia viridis*, valve view
**Nitzschia acicularis** (Kutz.) Wm. Smith

Elmore 1921:145, pl. 20, figs. 772-774.
Tiffany and Britton 1952:286, pl. 77, fig. 904.
West and Fritsch 1927:383, fig. 164G.

Cells lanceolate with long attenuated poles, about 66 microns long by 3.2 microns wide, cell length quite variable; have remarkable powers of locomotion for a diatom; keel marginal with small dots (carnal dots) along the raphe which follows the keel; striations very fine with about 18 in 10.0 microns; keels are diagonally opposite each other occurring on different girdle faces; very common in many collections of algae.

Fig. 32. *Nitzschia acicularis*, valve view
Surirella ovalis Brebisson

Elmore 1921:150, pl. 21, figs. 795-806.
Tiffany and Britton 1952:296, pl. 79, fig. 922.
Wolle 1890, pl. 53, figs. 7-8.

Cells not isopolar, usually not twisted, 20.7-27.6 microns broad, 24.2-64.5 microns long, sometimes larger; valves ovate, broadly ovate or ovate-lanceolate, quite variable; costae measured 5 per 10.0 microns, short and marginal; finer transverse striations present, about 14-18 per 10 microns; common in many algae collections.

(1) A small stream, Ellis County, 1/2 mile north of Schoenchen, water 1 degree C., 1-25-59.

Fig. 33. Surirella ovalis, valve view
Merismopedia glauca (Ehrenb.) Naegeli

Hylander 1928:40-41.
*McNaught 1920:150, pl. 2, fig. 2

Cells up to 4 microns broad, finely granular, light blue-green in color, grouped in colonies of 4, 16, 32 or 64; colony a flat plate; cells ovate, regularly arranged to form quadrangular colonies, form colonies 13.8 microns broad and 17.2 microns long for a colony of 16 cells when each was dividing, with cells 3.5 by 4.3 microns (see fig. 34); usually found mixed with other algae but also appears free floating; colonies enclosed by a hyaline, homogeneous gelatinous matrix.

(1) Smoky Hill River, Ellis County, Antonino bridge, 10-3-58.
Fig. 34. *Merismopedia glauca*
Microcystis aeruginosa Kuetzing
Anacystis cyanea (Kutz.) Dr. and Daily
Clathrocystis aeruginosa (Kutz.) Henfrey

Geitler 1932a:137, fig. 590.
*McNaught 1920:150.
Prescott 1951:456-457, pl. 102, figs. 1-4.
Tiffany and Britton 1952:336, pl. 91, figs. 1053-1054.

Anacystis cyanea is the new proposed more comprehensive classification including a number of previously separate species; M. aeruginosa, however, has colonies clathrate, irregularly shaped masses of many spherical cells 4.3 microns diameter; cells crowded within a hyaline, homogeneous gelatinous mass; cells blue-green to black, very granular, many pseudovacuoles; colonies float high or in winter may grow on substratum; found commonly with Anabaena flos-aquae and Aphanizomenon flos-aquae; toxic to fish and other animals.

(1) Smoky Hill River, Trego County, 1/2 mile below Cedar Bluff Dam, 10-5-58, water 55 degrees F., pH 5.0.

(2) Cedar Bluff Reservoir, Trego County, 11-7-58.
Fig. 35. *Microcystis aerginosa*
Oscillatoria limosa (Roth) C.A. Agardh

Geitler 1932a: 944-945, fig. 598D.
Prescott 1951: 489, pl. 109, fig. 17.
Tiffany and Britton 1952: 342, 344; pl. 93, fig. 1076.
Tilden 1910: 65-66, pl. 4, fig. 6.

Trichomes about 15.9 microns diameter, not tapering, not capitate, not constricted at the cell walls; apical cell convex with outer wall sometimes slightly thickened; cells about 4.1 microns long, granular at the cross walls, olive to brown; sheath usually not apparent on trichomes.

(1) Smoky Hill River, Trego County, Cedar Bluff Reservoir, pH 5, 12-19-58.

(2) Big Creek, Ellis County, 3 miles west and 1/8 mile north of Yocemento, 4-4-59.

Fig. 36. Oscillatoria limosa
Oscillatoria tenuis Agardh

Geitler 1932a:959, fig. 611P-G.
*McNaught 1920:151-152, pl. 2 fig. 3.
Prescott 1951:491, pl. 110, figs. 8, 9, 14.
Tiffany and Britton 1952:346, pl. 93, fig. 1074.
Tilden 1910:71-72, pl. 4, figs. 17-18.

Attached or free floating but usually attached to mud bottom at Cedar Bluff Reservoir on the Smoky Hill River; found growing in up to two feet of water; cells 6.90-10.4 microns wide and 2.5-5.0 microns long; apex not capitate, does not taper; trichome curved at the apex in most specimens, sometimes straight; constricted at cross walls and granulate along the cross walls; plant mass usually bright blue-green although it can rarely be dull blue-green, plant mass usually brighter than most species of Oscillatoria found in Ellis and Trego Counties.

(1) Smoky Hill River, Trego County, Cedar Bluff Reservoir, Cove III, Water 74 degree F., pH 6.0, 9-21-58.

(2) Spring Creek, Trego County, 1 1/10 mile west of east county line on U.S. 40, 1-14-58.
Fig. 37. *Oscillatoria tenuis*, apex curved down
Spirulina major Kuetzing

*McNaught 1920:153, pl. 2, fig. 6.*
Prescott 1951:480, pl. 108, fig. 11.
Tiffany and Britton 1952:354, pl. 97, fig. 1124.
Tilden 1910:87, pl. 4, fig. 47.

Trichome diameter about 1.6 microns, spiral diameter 3.5 microns, trichome making a regular spiral, pale blue-green in color; usually found mixed with other algae.

(1) Smoky Hill River, Trego County, 200 yds. below Cedar Bluff Dam, 6-22-58.

(2) Smoky Hill River, Trego County, Cedar Bluff Reservoir, 9-21-58.

Fig. 38. Spirulina major
Cells 5.2-6.9 microns in diameter, 6.9-20.0 microns long; akinetes about 6.9 microns diameter and 32.0-70.0 microns long; heterocysts about 6.9 microns and about 15.5 microns long or longer; trichomes blue-green to black, parallel in tapering bundles of a few to many trichomes; trichomes very fragile, float high in the water, taper at both ends; heterocysts slightly larger than vegetative cells in diameter and are oblong or sometimes cylindrical, found in the mid-trichome region; akinetes cylindrical and found in the mid-region but not adjacent to the heterocyst; toxic to animals (Ingram and Prescott, 1954).

(1) Smoky Hill River, Trego County, Cedar Bluff Reservoir, December 1958.
Fig. 39. *Aphanizomenon flos-aquae*, tapering bundle of trichomes

Fig. 40. *Aphanizomenon flos-aquae*, akinete
Fig. 41. *Aphanizomenon flos-aquae*, heterocyst
Anabaena flos-aquae (Lyngbye) Brebisson

Cells 6.9-7.1 microns in diameter and up to 9.0 microns long; heterocysts slightly more in diameter and usually globular in shape, 7.5-8.6 microns in diameter; akinetes 10.3-10.7 microns diameter by 10.7-19.6 microns long; akinetes sausage-shaped and often curved; trichomes blue-green; plant masses green to blue-green; trichomes usually coiled and in tangled masses, sometimes solitary; differs from the references listed above in that the akinetes and heterocysts are usually not found side by side but separated by one or more vegetative cells, this could be a new species but appears to fit A. flos-aquae in other respects; cells very granular with conspicuous Pseudovacuoles; has been found in conjunction with Microcystis aeruginosa on the Smoky Hill River, Trego County and north of Hays in a small stream it was found in nearly pure form; this is a toxic species to some animals.

(1) Smoky Hill River, Trego County, 1/2 mile below Cedar Bluff Dam, water 55 degrees F., pH 5.0, 10-5-58.

(2) Small stream, Ellis County, 2 miles north and 1/8 mile east of Hays, 6-27-59.
Fig. 42. Anabaena flos-aquae
CONCLUSION

There are 30 species described in this thesis. This represents 4 divisions, 5 classes, 11 orders, 19 families and 26 genera of algae. There are 10 of these species that may be new for the state, but further checking of the literature must be made. There were several other species that were not included in this thesis because of time and space limitations and these will have to remain to be listed and described later.

The ten species that possibly have not been listed for the state previously are Gloeocystis gigas, Scenedesmus opoliensis, Closterium moniliferum, Cosmarium vexatum, Bumilleria sicula, Fragilaria capucina, Diatoma vulgare, Nitzschia acicularis, Surirella ovalis, Oscillatoria limosa and Aphanizomenon flos-aquae.

There were a number of species of Oedogonium, Spirogyra and at least one Zygnema that was found but not enough information was found to verify identification. Found in smaller quantities were Mougeotia and an occasional Ulothrix. There are a great many diatoms remaining to be identified. In the blue-green algae several Oscillatoria, at least one Lyngbya and several Phormidium remain to be identified.

Photography was found very useful in supplementing a written description of each species found and whenever possible specimens were dried on mica slides or preserved in bottles. The color slides made in the study were found useful to illustrate lectures and the black and white prints made from copy negatives were found excellent for everyday use while making further studies of the species or for future
identification purposes.

The algae preserved in this study are the beginning of a new section in the Elam Bartholomew Herbarium, Fort Hays Kansas State College, that will contain preserved fresh-water algae.
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