75-21,830

TAYLOR, Constance Elaine Southern, 1937-
EUTHAMIA GYMNOSPERMOIDES (COMPOSITAE).

The University of Oklahoma, Ph.D., 1975
Botany

THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

EUTHAMIA GYMNOSPERMOIDES (COMPOSITAE)

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

CONSTANCE ELAINE SOUTHERN TAYLOR

Norman, Oklahoma

1975

EUTHAMIA GYMNOSPERMOIDES (COMPOSITAE)

APPROVED BY

DISSERTATION COMMITTEE

ACKNOWLEDGEMENTS

My deepest gratitude is given to Dr. George J. Goodman who first introduced me to the delights of plant taxonomy, and who has been a good friend and advisor in the study of the Compositae and particularly the Goldenrods.

My appreciation is extended to Dr. James Estes for his instructions on chromosomal determinations and his insight into the relationships of cytology and plant taxonomy. I wish to also thank Dr. Loran C. Anderson for sending me rhizome material and Dr. Theodore J. Crovello for information about Greene's 1896 travels.

Thanks is also given to the many herbaria who so generously allowed me use of their facilities in the pursuit of this study, and to those who lent me specimens.

Last, but not least, I wish to thank my husband, John, for his encouragement and for his companionship on the extensive field studies conducted throughout the United States and Canada. Also deserving of mention are my children Kathryn, Brian, and Kimberly, who have become good *Euthamia* and *Solidago* spotters, and who have spread many blotters out in the sun to dry.

The University of Oklahoma, particularly the Bebb Herbarium, Southeastern Oklahoma State University, Durant, and the U S Department of Agriculture Water Quality Laboratory, Durant, extended use of their facilities during this study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EUTHAMIA GYMNOSPERMOIDES (COMPOSITAE)

INTRODUCTION

The goldenrods are one of the more taxonomically difficult groups in the Compositae. They have all been aggregated into the single genus, *Solidago* L., or variously placed in a number of distinct genera: *Brachychaeta* T & G, *Brintonia* Greene, *Chrysoma* Nutt., *Euthamia* Nutt., *Oligoneuron* Small, *Petradoria* Greene, and of course *Solidago* (Kapoor & Beaudry 1966). Nuttall (1818) when describing the genus *Euthamia* expressed doubt as to its status, "A subgenus, or rather genus, reciprocally allied to *Solidago* and *Chrysocoma*."

Torrey and Gray (1942) placed *Euthamia* in *Solidago*, where it remained until Edward L. Greene (1902), "reinstated the then long supressed *Euthamia*." It has been accepted as a separate genus by Britton & Brown (1913), Rydberg (1931), Small (1933), Shinners (1951), and Correll & Johnston (1970). Others such as Fernald (1950), Mohlenbrock & Voigt (1959), Steyermark (1963), and Rosendahl & Cronquist (1945) have treated this group as a section of *Solidago*. Recent cytological and morphological studies have supported its separate status (Kapoor & Beaudry 1966, and Sieren 1970).

Euthamia may be characterized by having a corymbose inflorescence with sessile or short peduncled terminal glomerulate clusters; uniformity of its leaf morphology, being sessile, linear, and entire; the occurrence of glandular punctate dots which are biseriate glandular trichomes or colleters which secrete a viscid substance; a distinct tube and limb, with the stamens coming free at the tube summit; and the disk receptacle more or less fimbrillate. *Solidago*, on the other hand, has racemose to paniculate inflorescences; broader and usually petiolate leaves which are commonly toothed and usually without glandular-punctate dots; no pronounced difference in tube and limb; the filaments coming free from the corolla low in the tube; and the receptacles without fimbrillation.

Because of the similarity in floral and leaf morphology, species recognition in *Euthamia* is difficult. Usually a combination of characters is required. Of all the species, the *E. graminifolia-gymnospermoides* complex has been the most difficult. Of the more recent treatments, Croat (1970) considered the *gymnospermoides* taxon as a variety, *Solidago graminifolia* (L.) Salisb. var. *gymnospermoides* (Greene) Croat. Sieren (1970) considered it as a separate species, *Euthamia gymnospermoides* Greene. In this study, an emphasis was placed on understanding the amplitude of morphological variation in the species, the variation within a distinct genotype or clone, and the influence of various environmental conditions.

METHODS

Euthamia gymnospermoides was examined throughout its geographic range, but the major area of study was southeastern Oklahoma. Table 1 gives the location for certain populations which were chosen for study. Field studies were made in the spring and fall in south and north Texas, Louisiana, Alabama, and Arkansas. Several fall trips were made to Colorado, Wyoming, South Dakota, Kansas, Missouri, Illinois, Wisconsin, Minnesota, Michigan, and Ontario. The only species of *Euthamia* not observed in its natural habitat was *E. galetorum* Greene, a plant of southern Nova Scotia. Local populations of *E. gymnospermoides* near Durant, Oklahoma were monitored every other week for a year.

A transplant garden was established at my residence located in Durant, Bryan County, Oklahoma. A minimum of 5 clusters of rhizomes collected from each site in the fall or early spring were established in pots and set in the ground in full sun. Transplant material received from Dr. Anderson was divided into 2 pots per site. *Euthamia gymnospermoides* was transplanted from Blue River, Lake Texoma Roosevelt Bridge, Hockley, Emporia, and Manhattan. *Euthamia leptocephala* (T & G) Greene was obtained from Angelina River and Brazos. *Euthamia tenuifolia* (Pursh) Nutt. was transplanted from Dauphin Island, and *Euthamia occidentalis* Nutt. from Sterling.

Capitular development varies within a population allowing

TABLE 1

STUDY SITES AND LOCATIONS

EUTHAMIA GYMNOSPERMOIDES

Audrain	Missouri, Audrain Co., clone growing along fence 6 mi west and 5 mi south of Laddonia. J & C Taylor 12032.
Blue River	Oklahoma, Bryan Co., section line road 7 mi east and 0.75 mi south of Durant, north of old highway 70, sandy road bank. J & C Taylor 9148.
Coal Strip Mine	Oklahoma, McIntosh Co., nearly barren mound adjacent to abandon coal mine pit, 4 mi east of Checota.
Durant Seep	Oklahoma, Bryan Co., 1.25 mi east and 2 mi north of Durant. Revegetating old spring and seep cleared about 50 years ago.
Emporia	Kansas, Lyon Co., seepy hillside at the north edge of town near city park, Emporia.
Estelle Drive	Oklahoma, Bryan Co., 1 mi north, 1.5 mi west of Durant about 50 yards south of the intersection of Estelle Drive and Chuckwa Street, gentle north facing slope. J & C Taylor 12393.
Gladstone	Illinois, Headerson Co., growing in wet depression adjacent to Gladstone Lake in the Headerson County Conservation Area. J & C Taylor 12047.
Greenleaf	Oklahoma, Muskogee Co., revegetating pasture just south of the Youth Camp at Greenleaf State Park, 18 mi southeast of Muskogee. J & C Taylor 10263. The clones were located in the basin of a drainage pattern, an adjacent drained site, and a third in an open stand of Rhus glabra.
Hockley	Texas, Harris Co., wet roadside, U S Hy 290, just southeast of Hockley city limits.
Kingston	Oklahoma, Marshall Co., frequently horse grazed pasture, triangular in shape, located at the east edge of Kingston. J & C Taylor 9274 and 9275.

Lake Texoma Clones A, B, C, C, and E.	Oklahoma, Bryan Co., grazed Corps of Engineers public lease land adjacent to Lake Texoma, 3 mi east of the end of Roosevelt Bridge, and 10.8 mi west of Durant. NW¼, NE¼, Sec. 33, T6S, R7E. All located within the same 0.5 acre. Clone A (J & C Taylor 12440 and 15154), Clone B (J & C Taylor 12441 and 15155), Clone C (J & C Taylor 12442 and 15156), Clone D (J & C Taylor 12443 and 15157), Clone E (J & C Taylor 12444 and 15158).
Lake Texoma Roosevelt Bridge	Oklahoma, Bryan Co., 2 mi east of the west end of Roosevelt Bridge across Lake Texoma, 11.5 mi west of Durant. NW¼, NW¼, Sec. 33, T6S, R7E, J & C Taylor 9277.
Manhattan	Kansas, Riley Co., just northeast of Manhattan, obtained from Dr. Loran C. Anderson.

EUTHAMIA LEPTOCEPHALA

Angelina River	Texas, Angelina Co., floodplain of the Angelina River, 11 mi south of Nacogdoches.
Brazos	Texas, Brazos Co., transplanted from the Manhattan, Kansas garden of Dr. Loran C. Anderson (No. 3180).

EUTHAMIA OCCIDENTALIS

Sterling	Colorado, Logan Co., from the floodplain of the Platte River, just east of Sterling. J & C Taylor 8970.

EUTHAMIA TENUIFOLIA

Dauphin Island	Alabama, Mobile Co., from the pine woods at the east side of the Audubon Bird Sanctuary, located at the east end of Dauphin Island. J & C Taylor 12855.

clonal identification. This marked distinction made it possible to ascertain whether a particular clump of plants was a single clone or a mixture of several genotypes. Other characters, such as the unusual growth pattern of some inflorescences of an Estelle Drive clone, were confirmation of recognition of clonal habit.

Self fertilization and/or apomixis capabilities were studied by the exclusion of pollinators from inflorescences at the Estelle Drive and Durant Seep locations. Inflorescences were covered with double layers of nylon stocking while still in bud. After some over-wintering had occurred naturally on the plant, heads were harvested in January, stored in bottles, and examined for fruit maturation.

Germination experiments commenced on April 2, when fruits from covered and uncovered heads were placed on filter paper in 10 sterile petri dishes and flooded with distilled water. Dishes were incubated at room temperature under two conditions: in a dark cabinet and on a sunny west window shelf. A second set of germination experiments were conducted when cross pollinated fruits were placed on soil surface of pots containing sandy loam. They were subirrigated every other day, with some drying of the soil surface occurring. Another set of 100 achenes were scattered on the soil surface of pots placed in a pan containing 6 cm of water, which kept the soil surface continually wet. The effect of fruit age on germination was examined by using fruits collected in January 1972 and stored in jars until March 1973. Fruits from uncovered inflorescences were grown in flooded sterile petri dishes incubated in the light at room temperature.

Drought experiments were conducted with _E. gymnospermoides_ from

Lake Texoma Roosevelt Bridge, and with E. leptocephala from Angelina River. Four pots of each species were removed from the ground, set in a metal pan, saturated with water, and placed in partial shade to slow drying. The plants received only one supplementary watering during a brief rain. Plants were allowed to dry until all upper portions of the plants had permanently wilted. The pots were then rewatered and kept moist to check for rhizome survival.

Flowering phenology was studied in the transplant garden by marking individual inflorescences with colored yarns and monitoring them daily to determine flowering sequence. During a 5 day period, plants were examined from the southern area of range in the Red River valley in Oklahoma to its northern range in Illinois, and relative flowering time was noted.

Chromosome material was collected from 10 populations: 5 from Lake Texoma, 3 from Estelle Drive, and 1 each from Audrain and Gladstone. Buds were killed and fixed in a 6 (chloroform): 3 (95% ethanol): 1 (glacial acetic acid) solution, washed with 3 changes of 75% ethanol, and then stored or immediately stained with alcoholic carmine-HCl. The florets were dissected in 45% glacial acetic acid, mixed with Hoyer's mounting medium, and then squashed (Anderson, 1954).

Plant density was determined with the aid of a 22.5 cm^2 wire frame. Depending on whether the number of plants to be collected was 100, 50 or 30, data or collections were made from the 10, 8 or 5 plants nearest the left toe tip at predetermined paces through the population. Percent branching and apical meristem damage is based on 100 plants. Fifty plants were collected from each of the following: Coal Strip Mine, Sapulpa, Gladstone, 3 clones from Greenleaf, and 5 clones from Lake Texoma. An additional 30 plants were collected on the same date, one year later, from each of the 5 Lake Texoma clones. Plants were measured for some or all of the following data: Total height, height at which inflorescence branching commenced, apical meristem damage, length of secondary leaves, width of secondary leaves, length of primary stem leaves, width of primary stem leaves, number of heads on the ultimate peduncle, height of involucral bracts, number of ray flowers, number of disk flowers, total flowers, and flowering condition.

The following herbaria cordially extended to me the use of their facilities for the examination of their herbarium specimens of Euthamia and Solidago: CS, DUR, KSTC, LAF, MIN, NLU, OKL, OKLA, RM, SMU, UNA, USTA. The following herbaria loaned Euthamia and Solidago material: LAF, COLO, OKL, MO, US. Sets of specimens collected during this study are deposited at Durant (DUR), Norman (OKL), and Dallas (SMU).

RESULTS

TRANSPLANT STUDIES All species of *Euthamia* were easily transplanted if rhizomes were kept moist. *Euthamia gymnospermoides* transplanted from both very wet seeps and from upland prairie situations grew and flowered in the prairie conditions of the transplant garden without supplementary watering. *Euthamia leptocephala* transplanted from the floodplain of the Angelina River grew well in shaded and sunny well-drained locations, surviving southeastern Oklahoma's summer drought periods. Plants from Hockley, referred to *E. pulverulenta* Greene, dropped their primary stem leaves at the same time and could not be readily told apart from *E. gymnospermoides* from Lake Texoma, Emporia, and Manhattan.

Euthamia tenuifolia, transplanted from a pine woods on Dauphin Island, grew readily and survived a sunny location without supplementary watering. On the other hand, *E. occidentalis* transplanted from Sterling was planted in a sunny location. The sole survivor required frequent supplementary watering to prevent wilting. It was subsequently relocated in a shaded spot on the north side of the house, but it did not survive the next summer.

PHENOLOGY In southern Oklahoma, emerging leaves appear as early as mid-January, and growth continues somewhat slowly until warm weather. Sprouting from rhizomes and growth of new plants continues throughout early spring. A specimen from Lake Texoma Roosevelt Bridge transplanted to my office was successively measured for height: Feb. 11-4.8 cm; Feb. 21-5.6 cm; Feb. 28-8.9 cm; March 8-17.0 cm; March 22-25.9 cm; and May 21-36.7 centimeters. In May, secondary branching begins, and by late June, much of the total plant height has been obtained.

Flowering is from August in northern populations of E. gymnospermoides to late October in south Texas populations. About one-half of the involucres of a single clone open within 2 days. These are typically the terminal heads. Total flowering time for any given clone may be as long as three weeks as the final late flowering heads come into bloom. In a single population, some plants of E. gymnospermoides will have completed flowering before others even commence. On the monitored plants, all had 4 disk flowers and 9-12 ray flowers. The sequence of flowering within an involucre is summarized in Table 2.

REPRODUCTIVE BIOLOGY In insect exclusion experiments, Euthamia gymnospermoides produced mature fruits in all flowers in both covered and uncovered inflorescences. Two fruit sizes were observed under both treatments, with plump fruits constituting less than 1 % of the mature achenes.

The number of plants producing flowers was variable. On a badly eroded hillside east of Ardmore, one population had only a few plants, where the soil was deeper, producing flowers. This was less than an estimated 2 % of all plants. The percent of plants not producing flowers in Lake Texoma Clones A-E in 1972 was 24, 16, 14, 18, 2, and in 1973 was 52, 58, 39, 23, 20.

A pleasant, sweet odor is associated with flowering of the disk

TABLE 2

FLOWERING PHENOLOGY

Day	Ligulate Flowers	Tubular Flowers
1	Involucre opens	
2	1-3 corollas extended	
3	Additional corollas extended	First one or two flowers open, pollen presented in afternoon
4	All styles exerted	First opened flowers with exerted styles, remaining flowers open and by afternoon present pollen
5	Styles exerted	Pollen depleted, all styles exerted
6	Styles exerted	Styles exerted
7	Some corollas turning brown	Some corollas turning brown
8	Continued wilting	Continued wilting

blossoms. It is neither strong nor long lasting. Pollination is entomophilous. Of the numerous visiting insects, none were noted which seemed to be oligotropic, preferring only _E. gymnospermoides_. The insects visiting the plants were different from one location to another. Very frequently encountered were beetles (Silphidae), which were also common on numerous species of _Solidago_ throughout the great plains. Other common visitors included honey bees (Apidae), bumble bees (Bombidae), wasps (Vespidae), bee flies (Syrphidae), and solidary bees (Andrenidae). The latter are common pollinators of _Solidago_ (Percival, 1965).

GERMINATION Seeds from both disk and ray flowers and both regular and plump seeds germinated. However, under experimental conditions, the highest germination obtained was only 7.5 %. Best results occurred in petri dishes under flooded conditions incubated in a sunny location. Germination was not diminished by storage of seeds for 14 months. Results of the various germination experiments are given in Table 3.

TABLE 3

GERMINATION OF *EUTHAMIA GYMNOSPERMOIDES* SEEDS

Experimental Conditions	No. of Seeds	No. Germinated	Percent
Germination in Petri Dishes			
Bagged Plants			
Incubated in light	150	10	6.6
Incubated in dark	75	0	0.0
Open Pollinated Plants			
Incubated in light	158	3	1.9
Incubated in dark	139	1	0.7
Stored 14 months	134	10	7.5
Germination on soil	200	0	0.0

PLANT DENSITY Density of *E. gymnospermoides* was determined from upland and bottomland portions of 2 pastures. Results of the 25 quadrat samples taken from each location are given in Table 4. Plant density is partially determined by rhizome length. Twenty-five rhizomes measured in January in the Lake Texoma Roosevelt Bridge upland pasture averaged 16.9 centimeters. Each plant produced 3 or 4 rhizomes. Soil texture analysis of the Woodbine formation, which underlays the pasture, is 78 % sand, 15 % silt, and 7 % clay (Taylor 1967). A sparce roadside population on a structureless and sandy soil hilltop, 2 mi west of Mead, had long rhizomes. The longest measured 115 centimeters. A population located on the Goodland limestone, 1.5 mi west of Lake Texoma State Park, Marshall Co., Oklahoma, had very short rhizomes. Although not measured for exact length, all those dug up appeared to be less than 10 cm in length. Taylor (1967) reported 63 % sand, 13 % silt, and 24 % clay for the Goodland limestone. From field observations, digging, and rhizome measurements, it appears that an important environmental factor affecting rhizome length is soil texture.

TABLE 4

DENSITY OF PLANTS PER 22.5 CM^2

Location	Plants/Sample	Stems/Sample
Lake Texoma Roosevelt Bridge		
Upland grazed pasture	5.5	6.1
Bottomland grazed pasture	2.6	2.9
Kingston		
Upland grazed pasture	1.2	3.2
Bottomland grazed pasture	1.2	5.1

DRY WEIGHT Because of the frequently deciduous nature of the primary stem leaves, I was interested in the amount of dry weight which the plant accumulated in its primary stem leaves. Results of oven drying of 50 plants from each of 4 clones collected on the same day in May are given in Table 5. The results were variable, with two having the stems and tips definitely weighing more than the primary stem leaves, one with nearly equal weight, and one with the leaves outweighing the stems.

TABLE 5

DRY WEIGHT OF STEMS AND LEAVES IN GRAMS

Location	Stems & Tips	Primary Leaves
Coal Strip Mine	9.2	12.1
Greenleaf		
Wet Depression	15.1	12.5
Drained	11.1	8.9
In Rhus	11.6	12.0

DRYING EXPERIMENTS Euthamia gymnospermoides reacted to desiccation by the drying and falling of the lower leaves of the primary stem while the upper leaves remained green and flexible. The E. leptocephala plants dried uniformly, with the leaves wilting and drying at the base and summit of the plant at the same time. When the completely dried pots were rewatered, all 4 pots of E. gymnospermoides had 2 or 3 new plants sprout from the rhizomes. In the 4 pots of E. leptocephala, only 1 plant in 1 pot sprouted. Euthamia gymnospermoides is usually not found in the upland prairie if the rainfall is less than 30 inches. The western extent of its range is confined to very moist situations, particularly in river floodplains, even though it is rather drought resistent. The western extent of its range as a prairie species is most likely determined by the moisture requirements of seed germination and survival rather than susceptability of the mature plant to drought. The different response to water stress by E. leptocephala may account for its occurring only in the wet forest regions of the south central United States.

MORPHOLOGICAL VARIATION Height at which branching occurs has been used not only to separate species of *Euthamia*, but to also aid in varietal segregation. *Euthamia gymnospermoides* was described by Greene (1902) as having branching below the middle. Several populations were examined under different environmental conditions and for consecutive years. Table 6 gives the percent of stems branched below the middle based on 100 plants from each location. Variation occurred not only from one stand to another, but in one stand in different years as the Kingston bottomland which had 10, 55, and 19 %, depending on grazing pressure. These observations indicated branching above or below the middle of the total plant height was related to grazing and insect damage of the apical meristem. Sampling was then made of the percent of stems in clones which had apical meristem damage (Table 7).

Measurements from 50 plants obtained from the 5 Lake Texoma clones on 5 Oct 1972 and from 30 plants obtained 5 Oct 1973 were analyzed. Table 8 gives the average, standard deviation, and extremes of the height of branching and total height for undamaged plants and for plants with apical meristem damage. The percent of plants in the clones with apical meristem damage are given in Table 7. In the undamaged plants the primary stem averaged 48.4–69.0 % of the total plant height. When all plants were included, the primary stem averaged 39.7–61.9 % of the total plant height. Thus branching may occur above, at, or below the middle of the plant.

Table 9 gives the average, standard deviation, and extremes of the length and width of primary and secondary stem leaves. All measurements are based on 50 plants except the Gladstone, Sapulpa, and

TABLE 6

PERCENT STEMS BRANCHED BELOW THE MIDDLE

Location	Habitat Condition	Percent
Lake Texoma Roos. Bridge	Upland grazed 1971	24.0
	Upland grazed 1972	26.0
	Bottomland grazed 1971	36.0
Kingston	Bottomland not grazed 1971	10.0
	Bottomland grazed 1972	55.0
	Bottomland not grazed 1973	19.0
Durant Seep	Near spring, not grazed 1971	4.0
	Near spring, not grazed 1972	4.0

TABLE 7

PERCENT STEMS WITH APICAL MERISTEM DAMAGE

Location	Habitat Condition	Percent
Estelle Drive	Depression	36.0
	In *Rhus*	14.0
Strip Mine	Poor soil	28.0
Greenleaf	Wet depression	18.0
	In Rhus	50.0
	Drained edge of depression	20.0
Lake Texoma		
Clone A 1972	Upland pasture	43.0
Clone A 1973	Upland pasture	32.2
Clone B 1972	Upland pasture	8.0
Clone B 1973	Upland pasture	48.0
Clone C 1972	Upland pasture	2.0
Clone C 1973	Upland pasture	32.2
Clone D 1972	Upland pasture	22.0
Clone D 1973	Upland pasture	35.5
Clone E 1972	Upland pasture	16.0
Clone E 1973	Upland pasture	64.5

TABLE 8

HEIGHT OF BRANCHING AND TOTAL HEIGHT IN CM OF FIVE CLONES

Clone & Date	Undamaged Plants			Damaged Plants		
	Avg.	SD	Extremes	Avg.	SD	Extremes
HEIGHT OF BRANCHING						
A 1972	46.0	9.3	32.5–65.5	26.5	11.9	1.3–52.0
A 1973	44.3	5.6	34.2–57.3	9.6	8.1	1.3–23.7
B 1972	41.6	6.2	29.4–59.2	31.5	12.7	5.5–47.0
B 1973	47.9	6.9	38.2–56.9	13.8	18.4	0.2–53.2
C 1972	47.5	7.3	28.0–63.5	27.6	–	27.6
C 1973	40.4	6.9	23.6–53.8	19.5	15.9	0.5–42.8
D 1972	48.1	7.4	25.4–55.6	31.4	12.7	5.5–47.2
D 1973	47.0	7.6	37.7–63.8	17.9	18.5	1.3–55.2
E 1972	34.7	6.4	20.2–48.2	21.1	13.8	2.0–46.3
E 1973	36.5	7.2	26.3–51.6	14.1	11.7	0.8–39.3
TOTAL HEIGHT						
A 1972	68.0	9.7	48.8–83.1	62.2	9.6	39.5–78.9
A 1973	65.6	12.0	34.4–81.2	54.6	7.0	44.1–65.5
B 1972	71.0	7.4	57.7–88.8	66.2	5.7	59.4–73.1
B 1973	69.4	8.1	43.6–82.2	74.5	6.3	64.1–84.6
C 1972	89.5	9.3	71.7–104.4	71.3	–	71.3
C 1973	83.4	8.9	64.1–104.5	72.2	10.8	49.9–84.1
D 1972	74.5	9.4	39.2–88.7	66.5	15.0	39.8–83.9
D 1973	81.3	10.2	50.7–95.0	68.0	7.6	47.4–83.9
E 1972	65.5	7.0	50.1–82.0	64.8	4.3	50.1–81.0
E 1973	63.5	9.5	55.7–90.0	62.3	7.7	43.4–75.6

TABLE 9

LENGTH AND WIDTH OF PRIMARY AND SECONDARY STEM LEAVES

Location	Leaf Length in Cm.			Leaf Width in Mm.		
	Avg.	SD	Extremes	Avg.	SD	Extremes
<u>PRIMARY STEM LEAVES</u>						
Estelle Drive						
Depression	7.0	1.3	3.0- 9.6	3.4	0.9	1.8-6.0
In <u>Rhus</u>	6.8	1.3	2.9- 8.7	4.9	1.0	2.8-7.0
Coal Strip Mine	4.9	1.1	2.3- 7.1	4.0	0.9	2.1-6.0
Greenleaf						
Drained	6.0	1.0	3.6- 8.0	4.0	0.6	2.9-5.0
Wet	6.0	0.9	3.7- 8.5	3.6	0.7	1.8-5.8
<u>Rhus</u>	7.2	1.5	3.6-10.2	4.2	1.1	2.5-7.0
Sapulpa	6.2	1.4	3.0- 9.0	2.0	0.3	1.5-3.0
Gladstone	8.4	1.2	6.0-10.5	4.5	0.8	3.0-6.2
<u>SECONDARY STEM LEAVES</u>						
Estelle Drive						
<u>Rhus</u>	5.9	0.4	5.4- 6.5	4.2	0.5	3.6-4.9
Coal Strip Mine	3.7	1.2	2.7- 6.6	3.5	1.0	2.4-5.5
Greenleaf						
Drained	4.6	1.2	2.7- 6.5	3.6	0.9	1.9-4.9
<u>Rhus</u>	6.2	1.3	3.4- 7.9	3.9	1.0	2.5-5.0
Sapulpa	3.8	1.0	2.0- 6.0	1.0	0.2	1.0-1.5
Gladstone	4.4	0.9	3.0- 5.5	2.0	1.0	1.4-3.0
Lake Texoma						
A 1972	4.9	0.5	3.2- 5.8	2.5	0.5	2.1-3.4
A 1973	5.0	0.4	3.5- 6.0	1.9	0.4	1.2-3.0
B 1972	5.0	0.6	3.7- 6.0	2.0	0.5	1.3-6.0
B 1973	5.3	0.4	4.0- 6.0	2.2	0.3	1.2-3.2
C 1972	3.6	0.4	2.9- 4.4	1.7	0.3	1.2-2.2
C 1973	6.6	0.5	4.4- 6.5	1.8	0.3	1.0-2.3
D 1972	6.9	1.1	4.9-10.6	2.5	0.7	1.3-4.2
D 1973	6.1	1.0	4.8- 7.2	1.9	0.6	1.5-3.0
E 1972	6.1	0.9	4.2- 8.0	2.3	0.4	1.5-3.4
E 1973	5.8	0.8	4.5- 7.0	1.7	0.3	1.0-2.0

1973 Lake Texoma clones, which are based on 30 plants. Variation within a clone may be as large as that of a mixed population, and average of the leaf length and width may vary slightly from one year to the next.

The variability of the stem and leaf morphology was expected from previous field observations. The variability of flower numbers and involucre size in individual clones was not. Examination of Table 10 shows that while involucre averages were similar for all clones, there could be a 1.5-2 mm range. The average number of ray flowers and disk flowers, again were very close, but anywhere from 8-14 ray flowers and from 3-8 disk flowers were found. Total flowers per head were generally 15, but again extremes ranged from 8-22.

Numerous flowers, mounted in Hoyer's mounting medium or in Klearmount were examined for differentiating characters. Although subtle differences were found, they varied so much they were discarded as of taxonomic value.

FIELD OBSERVATIONS AT TYPE LOCATION AND SYNONYM TYPE LOCATIONS Various manuals have used particularly the synonyms of *E. camporum* Greene, *E. media* Greene, and *E. pulverulenta* for various populations or portions of the range of *E. gymnospermoides*. Investigations were made of all of the type locations for these four names.

Euthamia gymnospermoides (Bush, October 6, 1894, Sapulpa, Indian Territory). Extensive exploration of the adjacent countryside was made around Sapulpa, Creek Co., Oklahoma. Populations were located only on the north side of town, the surrounding countryside in the other directions generally being forested. At the collection site, *Euthamia* formed a dominant part of several pastures covering over 40 acres on both

TABLE 10

FLORAL MEASUREMENTS OF CLONES AND POPULATIONS

Location	Inv. Length in mm		No. of Ray Flowers		No. of Disk Flowers		Total No. of Flowers	
	Avg.	Extremes	Avg.	Extremes	Avg.	Extremes	Avg.	Extremes
CLONE								
A 1972	4.6	4.0-5.4	10.9	9-14	5.0	4-8	15.9	13-22
A. 1973	3.8	3.0-5.0	9.6	8-11	5.3	4-7	14.9	13-17
B 1972	5.2	4.4-5.8	10.2	8-13	5.1	3-7	15.3	11-19
B 1973	4.9	4.0-5.4	11.2	10-13	5.7	3-8	16.9	15-19
C 1972	4.8	4.0-6.0	9.0	7-13	5.5	4-7	14.5	13-18
C 1973	5.0	5.0-5.2	9.5	8-11	5.5	5-7	15.0	13-17
D 1972	4.7	4.2-5.1	9.7	8-12	5.4	3-8	15.1	13-20
D 1973	5.0	4.8-5.2	9.4	8-11	5.6	5-7	15.0	12-17
E 1972	4.7	4.0-6.0	9.3	8-11	5.0	4-7	14.3	8-20
E 1973	4.9	4.5-5.2	10.4	8-12	5.1	4-6	15.5	12-17
POPULATION								
GLADSTONE	3.8	3.0-4.2	8.6	6-11	5.4	4-7	14.0	10-17
SAPULPA	3.7	3.0-5.0	9.9	8-13	5.5	4-7	a5.5	13-18

sides of St. Hy. 97, north of Turner Turnpike. This is the most probable location of the type specimen.

Euthamia camporum (Greene, Sept. 11, 1896, banks of the Platte River, Sterling, Colorado). Greene's itinerary for this collection trip brought him through the Rockies by way of Marshall Pass, Canon City, LaSalle, and down the Platte River to Sterling where he collected the Euthamia specimen. Extensive field search was made of the area near Sterling, which is disturbed through man's activities. The entire sandy flats of the river at this location are now occupied by luxuriant growth of Euthamia occidentalis. Since the E. camporum type is the only known collection of E. gymnospermoides for Colorado, it is possible that this species is no longer extant in that state.

Euthamia media (Patterson, Sept. 1876, banks of the Mississippi River at Oquawka). Extensive searches up and down the river in and adjacent to Oquawka failed to yield any populations of Euthamia. The town occupies much of the area adjacent to the river, and a high levee has been built to protect the town from floods. The nearest population of Euthamia located was in Headerson County Conservation Area adjacent to Gladstone Lake, about 5 miles south of Oquawka.

Euthamia pulverulenta (Thurow, 1890, Hockley, Texas). Plants were readily located in the vicinity of Hockley by examining areas where Andropogon glomeratus (Walt.) BSP, a plant of moist habitat, was growing. This visit was made in the spring for two reasons. First, transplant material was collected. Second, specimens from south Texas generally have only flowering heads and a few leaves present in the upper portion. This enabled extensive examination of primary stem leaves which are usually not available on herbarium specimens.

CHROMOSOME NUMBER Chromosome counts were obtained for three locations, Estelle Drive, Lake Texoma Clone D, and Gladstone. All counts were $n = 18$. Sieren (1970) reported one count of $n = 18$ for an Illinois population.

EVALUATION OF THE TAXONOMIC CHARACTERS

Because of the similarity of the flowers in *Euthamia*, leaf morphology, inflorescence characters, and pubescence have long been used to separate the various taxa. The taxonomic importance of the height of inflorescence branching was extablished by Greene (1902) in his species descriptions, and has been used with modification ever since (Croat 1970, Sieren 1970). His original descriptions pertinent to branching were *E. gymnospermoides* "freely branched from near the base"; *E. pulverulenta* "rather freely branched from the middle"; and *E. media* "fastigiately corymbose above the middle". Branching was not mentioned for *E. camporum*. Table 6 contains data compiled from Oklahoma populations concerning the number of plants branched below the middle. When it was determined low branching was due to a damaged apical meristem, later samples (Table 7) evaluated this condition. Not only does branching below the middle vary from one location to another, it varies at one location during different years. If apical meristem damage occurs when the primary stem is more than about 3 cm tall, secondary branching occurs. These branches will have much smaller leaves (Table 9). Thus height of branching definitely influences the leaf morphology of the plant and totally alters the aspect presented by the herbarium specimen.

Studies made during the early spring determined some of the causes of apical meristem damage. Of the many possible hazards to the growing shoot, trampling and grazing by cattle or horses caused much of the damage, particularly during the early spring. Larger shoots and mature plants are unpalatable to these animals. Measurements made on 7 March of two populations showed this difference. A roadside population west of Mineral Bayou along U S Hy. 70 had an average height of 15.4 cm with a range of 10.0-22.2. A population in the Lake Texoma Roosevelt Bridge grazed field had an average height of 9.1 cm with a range of 5.5-13.6. In March, many plants were observed with an unusual wilted curl affecting the newly expanded leaves still enclosing the apical meristem. These plants contained either white or orange caterpillars, which were eating the apical meristem region. All of these plants produced secondary branching, did not have any primary stem leaves present during flowering, and the stem had so completely healed above the last branch, it was difficult to tell the apical meristem had been destroyed. When plant stems are broken or cut later in the season, the break can be more readily detected. Other than reducing the overall height of the plant, and causing low branching, this early use of the plant meristem by insect larva did not seem to affect flower or seed production. Attempts to capture the mature form, or hatch mature forms from excised stem tips failed. All larva died when the plant tip was removed.

When the five clones were collected and measured for total height and height of the stem where branching began, the plants were segregated into those which were undamaged, and those which had in some manner had the apical meristem destroyed. Table 8 is a compilation of the average, standard deviation and extremes of these measurements for undamaged and damaged plants. The branching of the inflorescence in the undamaged plants occupied an average of 25 % to 50 % of the total plant height. When all plants were included, the variation was more pronounced. This more nearly reflects the actual occurrence of herbarium specimens, where the inflorescence will generally occupy an average of 40 % to 60 % of the total plant height. This character can not be used for any type of varietal separation within the taxon.

Euthamia graminifolia and E. tenuifolia under field conditions were found to have inflorescences that occupied a smaller percent of the total plant height. This character is difficult to use if the specimen is represented only by the upper stem. Unfortunately, plant height is only infrequently included on a label.

The primary stem leaves are linear to lanceolate in outline. A compilation of measurements of primary leaves was given in Table 9. It must again be emphasized that in E. gymnospermoides, herbarium specimens from dryer habitats will not have these leaves. Their absence may be considered as a useful species differentiating character, as the other species retain them. These primary stem leaves have a prominent central vein with usually 1 faint lateral vein on each side, which are more visible, and sometimes only visible, on the undersurface of the leaf. In the northern portion of its range, robust specimens with wider leaves up to 10 mm in width will have 4 lateral veins, two on each side. At Gladstone, plants with either 2 or 4 faint lateral veins were collected. At the southern end of its range, E. gymnospermoides regularly has 3 veins, 1 prominent and 2 faint. The type of E. pulverulenta has no primary stem leaves, but the lower secondary stem leaves do have the same 1 prominent, 2 faint pattern. Spring field observations in south Texas showed that occasional plants with exceptionally narrow leaves had only 1 vein. Generally venation can be correlated with leaf width.

Venation is a common key character used to separate species. In some treatments, E. graminifolia has 5 leaf veins, E. gymnospermoides 3 leaf veins, and E. pulverulenta, E. tenuifolia, and E. leptocephala have 1 leaf vein. Others treat E. graminifolia as having 3 prominent veins and the other species with 1 vein prominent. Almost never is leaf type or surface designated. Thus depending on whether one examines primary stem leaves, secondary stem leaves, upper or lower leaf surfaces, any given plant may have leaves with 1, 3, or more vein counts. With proper leaf designation, venation does have some taxonomic value in species separation. It is absence of primary stem leaves coupled with confusion concerning number of veins, which has delayed the recognition of the Texas and Louisiana plants as properly belonging to E. gymnospermoides. Leaf venation is most useful in helping separate E. graminifolia from the other species.

Presence or absence of primary stem leaves in E. gymnospermoides was first noted by the microhabitat differences of the plants which still retained these stem leaves. If plants receive frequent rainfall during the growing season, the primary stem leaves are retained. These conditions prevail in the northern portion of its range in Illinois, Indiana, and portions of Missouri. In more southern regions, plants adjacent to lakes and along floodplains also have a more constant supply of moisture. In the wet prairies of Oklahoma and southern Texas and

Louisiana, summer is commonly dry. The plants in these situations respond by loss of primary stem leaves.

The glomerulate or pedunculate conditions of the heads has been used for distinguishing E. graminifolia from E. gymnospermoides. The character is, however, not entirely reliable. The more robust specimens of the latter species in the northern portion of its range will have heads glomerulate, while those in the south may frequently have many or all heads pedunculate. Usually E. graminifolia is densely glomerulate, but in Missouri the typical variety of this species may have heads only moderately glomerulate, or with abortion of heads, infrequently pedunculate. Sieren (1970) treated the glomerulate to pedunculate North and South Carolina specimens of this species as Euthamia hirtipes (Fernald) Sieren. Fernald (1946) considered E. hirtipes to be the result of hybridization between E. graminifolia and E. microcephala (now a part of E. tenuifolia). My own specimens of E. graminifolia from the Gulf Coast are only very slightly glomerulate, usually 3 or 4 heads per cluster.

Sieren (1970) also indicated E. tenuifolia has more compact inflorescences in the north. E. leptocephala always has pedunculate heads. Thus glomerulate heads, although useful, cannot be used by itself as a differentiating character between E. graminifolia and E. gymnospermoides. The evident frequency of pedunculate heads in the southern states might be attributed to the longer growing season. However, specimens of E. gymnospermoides from northern Indiana have been examined which do have pedunculate heads. Sufficient transplant specimens have not been maintained to determine yet the extent to which this character is controlled by heredity and is modified by climate.

Number of flowers per head has been used to differentiate E. gymnospermoides from E. graminifolia, the former generally having less than 20 flowers, the latter generally having more than 20 flowers. Sieren (1970) reported E. graminifolia as having usually 17-22 rays (extremes 11-35) and disk flowers 5-7 (extremes 4-13). The flower numbers of E. gymnospermoides were presented in Table 10. Croat (1970) reports E. graminifolia var. graminifolia as having many more florets (averaging 25 rays and 13 disks) than E. gymnospermoides. Yet, E. graminifolia specimens which I examined from Missouri generally had less than 20 flowers, and all my specimens of that species from the Gulf have less than 20 flowers. Because of the extreme variability found within a single clone and within populations growing in the same area, application of flower numbers must be used cautiously. We may generally say that E. gymnospermoides nearly always has total flowers less than 20, but E. graminifolia may have fewer or more than that number.

Pubescence is another taxonomic character that has been used with some success. All species are glabrous except E. graminifolia and occasional specimens of E. gymnospermoides. While typical E. graminifolia is designated as glabrous, a totally glabrous specimen is uncommon. This species is commonly very pubescent, but all gradations are found. Euthamia gymnospermoides is essentially glabrous. However, my own collections of this species from Gladstone do have some small amount of hairs on the peduncles and the lower veins of the primary stem leaves. This pubescence is more noticeable in the fresh plants than in the dried specimen.

Because of the extreme variability and overlapping similarity of taxonomic features, the separation of *E. graminifolia* and *E. gymnospermoides* has been questioned. "If a taxon is to be accepted as of specific (species) rank, both a significant differentiation of characteristics and a considerable degree of isolation are expected." (Benson 1962). Beaudry and Chabot (1959) reported numerous counts of n = 9 for *E. graminifolia*. Sieren (1970) and I have n = 18 counts for *E. gymnospermoides*. We may thus assume that these two groups have a considerable degree of isolation. The similarity of morphological characters, which makes differentiation of some herbarium specimens difficult, may be due to *E. gymnospermoides* having been directly derived by autopolyploidy from *E. graminifolia*. Either isolation has not been long enough to evolve morphological differences, or natural selection of the same characteristics in the two gene pools have occurred under the climatic conditions present where their ranges overlap.

Application of information obtained from the study of species variability supports the division of the genus *Euthamia* into six species. The following treatment contains description and geographical range for *E. gymnospermoides*, the species studied. This is followed by a key to the genus, with geographical information given to supplement that presented in "A Taxonomic Revision of the Genus *Euthamia*" by Sieren (1970).

DESCRIPTION AND DISTRIBUTION OF *EUTHAMIA GYMNOSPERMOIDES*

EUTHAMIA GYMNOSPERMOIDES Greene

Euthamia gymnospermoides Greene, Pittonia 5: 75. 1902.

Euthamia media Greene, Pittonia 5: 74. 1902.

Euthamia camporum Greene, Pittonia 5: 74. 1902.

Euthamia pulverulenta Greene, Pittonia 5: 75. 1902.

Euthamia chrysothamnoides Greene, Pittonia 5: 76. 1902.

Solidago moseleyi Fernald, Rhodora 10: 93. 1908.

Solidago gymnospermoides (Greene) Fern., Rhodora 10: 93. 1908.

Solidago camporum (Greene) A. Nelson, Man. Bot. Rock. Mts. p. 507. 1909.

Solidago graminifolia (L.) Salisb. var. *camporum* (Greene) Fern., Rhodora 17: 12. 1915.

Solidago media (Greene) Bush, Amer. Midl. Nat. 5: 167. 1918.

Solidago chrysothamnoides (Greene) Bush. Amer. Midl. Nat. 5: 172. 1918.

Euthamia glutinosa Rydberg, Brittonia 1: 102. 1931.

Solidago perglabra Friesner, Butl. Univ. Bot. Studies 3(1):61. 1933.

Solidago texensis Friesner, Butl. Univ. Bot. Studies 4: 196. 1940.

Solidago gymnospermoides (Greene) Fern. var. *callosa* S. K. Harris. Rhod. 45: 413. 1943.

Solidago graminifolia (L.) Salisb. var. *media* (Greene) S. K. Harris, Rhodora 45: 413. 1943.

Solidago graminifolia (L.) Salisb. var. *gymnospermoides* (Greene) Croat, Ann. Mo. Bot. Gard. 57: 250. 1970.

Perennial herbs, spreading into large colonies by means of underground rhizomes which vary in length from less than a centimeter to over 45 centimeters. Each plant producing regularly 1 to 4 rhizomes which in turn may produce usually one to sometimes two or more new stems. Rhizomes shallow, commonly less than 6 cm in depth. New plants, at least in the southern portion of its range, growing out of the ground in late January and early February, although numerous stems may appear above ground long after the first shoots. No basal rosettes present. Growth continues rapidly through spring, the inflorescence branching occurring by June. By midsummer, most of the plant height has been obtained. Plants usually 6 to 9 dm. in height, but may be from 4-11 decimeters. Inflorescence branching low, the upper 25 to 60 % of the plant rather bushy with no predominant primary stem axis maintained in the secondary branching. Herbage glandular punctate, and glabrous, although occasional plants in the northern region may have sparse hairs on the veins of the lower leaf surface. Primary stem leaves linear to lanceolate, width averaging about 3.4-4.9 mm (extremes 1.8-7.0 mm) and averaging 5.0-7.0 cm in length (extremes 2.3-10.2) with 1 main vein and a pair of lateral fainter veins which are more visible on the undersurface, frequently early deciduous during drying conditions, and thus frequently absent in specimens from the southern portion of range. Secondary stem leaves approximately the same as primary stem leaves except for reduced size, averaging about 3.5-4.5 mm wide and 1.9-7 cm long, remaining linear into the inflorescence where they may over top the flowers. Destruction of the apical meristem above the first 2 cm results in secondary branching with small leaves typical of regular inflorescence branching. Heads pedunculate to slightly glomerulate, phyllaries usually shiny varnished and lanceolate, varying from 3-6 mm in height, with or without a darker area around the central nerve. Heads usually turbinate, receptacles more or less fimbrillate, averaging 8-10 rays (extremes 6-14) and 5 disks (extremes 3-8) and total flowers averaging 14-17 (extremes 8-22). All flowers fertile, yellow. Rays with the style branches uniformly linear, the disk flowers with style branches shorter, slightly flattened, and slightly rhomboid. Anthers connate, rounded at the base, acute at the tip, filaments becoming free at the summit of the tube. Pappus of capillary bristles, about as long as the disk flowers. Achenes pubescent, gradually dispersing from the head during the fall to early spring. Chromosome number n = 18.

TYPE LOCALITY: Sapulpa, Indian Territory, October 6, 1894, B. F. Bush 252. (ND-G, isotype-G).

GEOGRAPHICAL DISTRIBUTION: Plants of wet habitats, range nearly coinciding with the mosaic of Bluestem Prairie (Andropogon-Panicum-Sorghastrum) and Oak-hickory Forest (Quercus-Carya) mapped by Kuchler (1964). Common also in the Bluestem-sacahuista Prairie (Andropogon-Spartina) of south Texas and Louisiana. It has not been collected from the limestone derived blackland prairies of north central Texas. Extensive clearing and building of railroads and highways have provided man-made habitat for this plant. Its eastern edge of range seems to be defined by the shade of the eastern deciduous forest. At the northern and western edge, it is defined by the moisture necessary for germination and establishment. In the plains of Nebraska, Kansas, Oklahoma, and Texas, it is confined to the floodplains of rivers. In the wet prairies it is usually found near seeps, springs, and in depressions, but may also be an upland species. The distribution is indicated by dots on the map (Figure 1). Note the four locations on the Atlantic coast. Fernald (1937) reported E. gymnospermoides from Virginia. The map was compiled from the representative collections cited by Sieren (1970) and from the following collections:

ARKANSAS: BENTON: Illinois River at Robinson, 14 mi northwest of Fayetteville, Demaree 5494(OKL); FAULKNER: level wet soil, Conway, Demaree 13814(MO); LONOKE: rice prairies, Lonoke, Demaree 57406(SMU); PRAIRIE: west of Hazen, Moore 321055(FAY); ST. FRANCIS: open prairie between Goodwin and Wheatley, McDaniel 1034(FAY); SEBASTIAN: Massard Prairie, Armstrong, Sept. 10, 1940(FAY); WASHINGTON: Demaree 630(FAY).

DELAWARE: SUSSEX: margins of salt marsh, 1 mile west of Broadkill Beach, Massey 3062(OKL).

ILLINOIS: HENDERSON: Gladstone Lake, Henderson County Conservation Area, J & C Taylor 12047(DUR).

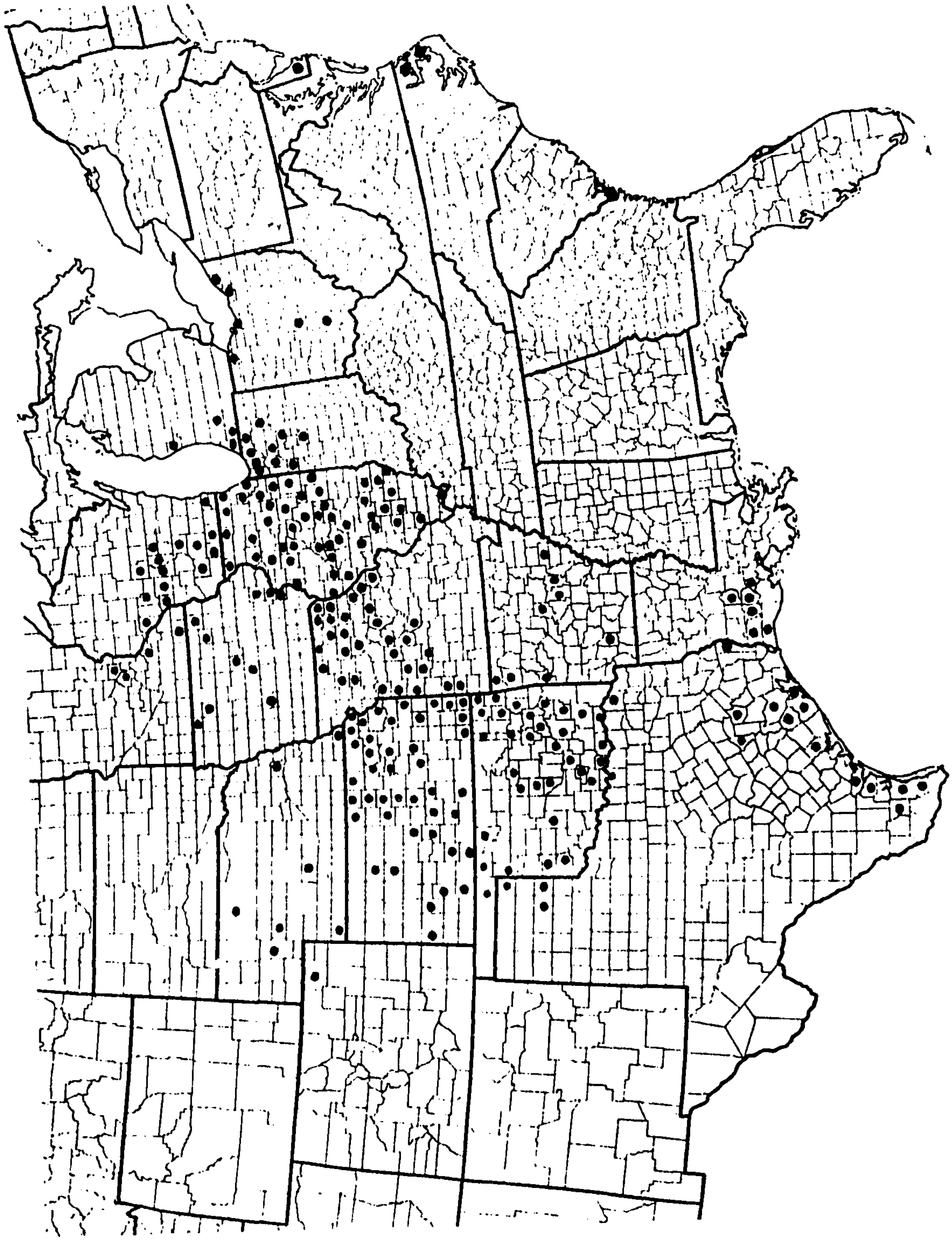
INDIANA: KOSCIUSKO: Chapman Lake, 0.5 mi west of Sutherland Landing, Friesner 23171(OKL).

IOWA: JONES: roadside ditch, Greenfield Twp. Cooperrider 3312(SMU); LEE: Skimek State Forest east of Farmington, Davidson, Sept. 17, 1954(SMU); LOUISA: SW¼, Sec 9, T75N, R4W, Davidson 1342(SMU).

KANSAS: GRAHAM: Alt. 2000, Imler 2039(OKL).

LOUISIANA: ACADIA: prairie about 2 mi east of Rayne, Thieret 16642(LAF); CALCASIEU: 2.5 mi southeast of Holmwood, McWilliams & Davis, Oct. 14, 1962(LAF); CAMERON: prairie section of Lacassine Natl. Wildlife Refuge, Fruge, Oct. 20, 1973(LAF); JEFFERSON DAVIS: roadside, 1 mi

Figure 1 Distribution map of Euthamia gymnospermoides.



northwest of Lacassine, J & C Taylor 15553(DUR,OKL,SMU);
LAFAYETTE: Just east of Lafayette-Acadia Parish Line, U S HY 90,
J & C Taylor 15551(DUR,OKL,SMU).

MISSOURI: ADAIR: prairie between Sublette and Kirksville, Steyermark 16163(MO); AUDRAIN: bottom prairie north of Farber, Steyermark 16293 (MO); BARTON: dry prairies, Golden City, Palmer 4587(MO); BOONE: 1.5 mi north of Hallsville, Jeffrey 305(MO); CALDWELL: prairie west of Nettleton, Steyermark 16114(MO); CASS: Brownhead, Sept. 6, 1864 (MO); CHARITON: prairie west of Salisburg, Steyermark 15993(MO); CLARK: prairie 2 mi north of Peaksville, Droset 1763(MO); DAVIESS: prairie 1 mi north of Winston, Steyermark 16095(MO); HENRY: just south of Gaines, Steyermark 7355(MO); Hickory; prairie at Wheatland, Steyermark 20230(MO); JASPER: south of Joplin, Trelease 592(MO); KNOX: prairie between Edina and Knox, Steyermark 16203(MO); LEWIS: prairie east of La Belle, Steyermark 16199(MO); LINN: prairie between Laclede and Linnens, Steyermark 16069(MO); MACON: prairie a mi south of Excello, Steyermark 16015(MO); MERCER: prairie 2 mi east of Princeton, Steyermark 17157(MO); MILLER: 2 mi west of Eldon, Droset 277(MO); PETTIS: prairie south of Sedalia, Steyermark 15936(MO); RALLS: Oakwood, Davis 6098(MO); ST. CLAIR: prairie near Taberville, Brown 147(SMU); ST. LOUIS: west of Ann Ave., Kirkwood, Lodewyks 76 (MO); SCOTLAND: prairie 3 mi east of Memphis, Steyermark 16217(MO); SHELBY: prairie between Shelbrina and Lakenan, Steyermark 16266(MO).

NEBRASKA: GARDEN: Cresent Lake Nat. Wildlife Refuge, Richardson & Robertson 1734(SMU).

OKLAHOMA: BRYAN: 4.5 mi northeast of Bennington, J & C Taylor 2484(OKL);

CADDO: east of Bridgeport, Waterfall 1815(c)(OKL); CARTER: 6 mi east of Ardmore, Hopkins 6344(OKL); CHOCTAW: 0.9 mi east of Boswell, J & C Taylor 9407(DUR); CLEVELAND: 3 mi south of Norman, Goodman 2761(OKL); GRAIG: 20 mi southeast of Nowata, Plice 12(OKLA); DELAWARE: 3 mi east and 3 mi north of Grove, Wallis 5949(OKL,SMU); GREER: floodplain, North Fork of Red River, 1.5 mi south of Mangum, J & C Taylor 14500(DUR,OKL); HARPER: 15 mi east of Buffalo, Smith 124(OKL); HUGHES: 18.1 mi north of Calvin, J & C Taylor 9252(DUR, OKL); HASKELL: roadside, 16 mi east, 0.5 mi north of Stigler, J & C Taylor 17036(DUR,OKL); JOHNSTON: 23 mi north of Durant, near Coleman, J & C Taylor 9233(DUR,OKL,SMU); LATIMER: slew, 1.1 mi west of Talihina, Waterfall 10541(OKLA); LOGAN: 4 mi southeast of Guthrie, Smith 907(OKL); MARSHALL: in field east edge of Kingston, J & C Taylor 9274(DUR,OKL,SMU); MAYS: 0.5 mi north and 1 mi west of Peggs, Wallis 5687(OKLA); MURRY: Platt Natl. Park, Merrill & Hogon 1629(OKL); MCINTOSH: 4 mi east of Checota, Strip Mine Site; MUSKOGEE: Greenleaf State Park, 18 mi southeast of Muskogee, J & C Taylor 10263(DUR,OKL); OKLAHOMA: 2 mi south and 1.5 mi east of Choctaw, Waterfall 2467(OKL); OKMULGEE: 0.25 mi west of Henryetta, J & C Taylor 9252(DUR,OKL); OTTAWA: 0.5 mi northeast of Quapaw, Wallis 5862(OKLA,SMU); PITTSBURG: north edge of Kiowa, J & C Taylor 17129(DUR,OKL): PONTOTOC: 5 mi south, 1 mi east of Allen, J & C Taylor 9246(DUR); PUSHMATAHA: wet meadow, 1 mi north of junction of St Hy 2 and U S Hy 271, J & C Taylor 8163(DUR); WASHINGTON: 15 mi north of Bartlesville, Engleman5003(OKL).

NORTH CAROLINA: DARE: Savanna, 2 mi south of Manteo, Ronoke Island, Godfrey & Fox 51038(SMU).

SOUTH CAROLINA: BEAUFORD: St. Helena Island, Godfrey 50914(SMU).

TEXAS: BRAZORIA: Angleton, between Anderson and Kiber Streets, Fleetwood 9978(SMU); BROOKS: Encino Division, Kings Ranch, Gould 6758(SMU); FT BEND: in Needville, Shinners 16482(SMU); GALVESTON: Texas City, north of Town, Turner 1728(SMU); GRAY: North Fork of Red River, 12 mi south of Lefors, Rte 291, Correll 38047(SMU); JACKSON: prairie south of Vanderbilt, Tharp & Barkley 13A151(SMU); KENEDY: 6 mi south of Norias, Shinners 17823(SMU); LIPSCOMB: valley of Wolf Creek, 0.25 mi north of Lipscomb, Wallis 7965(SMU); NEWTON: about a lake, 3 mi east of Newton, Correll 38170(LAF,SMU); SAN PATRICIO: 3 mi south of Ingleside, Jones 447(SMU); Red River: east of Avery, J & C Taylor 10671(DUR); WHEELER: south side of North Fork of Red River, 3.5 mi north of Shamrock, Cory 50254(SMU).

KEY TO THE GENUS *EUTHAMIA*

WITH COMMENTS ON THE GEOGRAPHICAL DISTRIBUTION OF THE SPECIES

Key to the Genus *Euthamia*

A. Inflorescence paniculate, secondary branches short, inflorescence not at all flat-topped. Plants glabrous, heads glomerulate, in very mesic habitats of the western United States. 1. *E. occidentalis*

A. Inflorescence corymbose, generally flat-topped, plants glabrous to variously pubescent, heads glomerulate to pedunculate, mesic to dry habitats, central and eastern United States and Canada.

  B. Leaves pustulate glandular punctate. Primary stem leaves always present, broadly linear to lanceolate, heads pedunculate. Common in lower Mississippi Valley. 2. *E. leptocephala*

  B. Leaves shiny glandular punctate. Primary stem leaves linear, present or absent, heads pedunculate or glomerulate.

    C. Heads pedunculate, branching of inflorescence occupying the upper one-fourth of plant and main stem axis maintained. Primary stem leaves generally less than 4 mm, frequently 1 to 2 mm wide, and commonly fastigiately branched. Plants of Atlantic and Gulf coastal plains, and east of Lake Michigan. 3. *E. tenuifolia*

    C. Heads glomerulate or pedunculate, inflorescence variable, primary stem leaves generally over 4 mm wide, plants rarely fastigiately branched.

D. Inflorescence small, stem simple to very near summit, plants nearly glabrous, heads campanulate, glomerulate. Plants of Nova Scotia. 4. _E_. _galetorum_

D. Inflorescence large, branching occurs in 15 percent or more of total plant height, plants glabrous to pubescent, heads campanulate to turbinate, glomerulate to pedunculate. Plants of central and eastern United States and of Canada.

E. Plants glabrous, very rarely with slightly hirsutellous peduncles. Heads pedunculate to slightly glomerulate in clusters of 3 or 4 heads. Inflorescence branching occupies 25 to 60 percent of the total plant height, and a primary stem axis not retained giving the plant a bushy appearance. Primary stem leaves, when present, with 1 main vein and usually 2 faint lateral veins. Plants of the prairie and a rare introduction along the eastern coast. 5. _E_. _gymnospermoides_

E. Plants abundantly pubescent to only slightly hirsutellous or even glabrous. Heads usually glomerulate in the northern range, but may be pedunculate along the southern coastal regions. Inflorescence branching occupies the upper 15 percent of the total plant height. Primary stem leaves present and usually with 3 prominent veins or rarely with 1 prominent vein and 4 fainter lateral veins. Plants widespread in the eastern and northern United States and Canada 6. _E_. _graminifolia_

1. EUTHAMIA OCCIDENTALIS Nuttall

This is the most distinctive of the species because of its paniculate inflorescence. It also requires the most mesic habitat, and is found growing from Washington south to California and scattered locations in Montana, Utah, Colorado, and Arizona. It was probably introduced east of the Rocky Mountains, and is now established in the Platt River floodplain from the Denver area north into Wyoming and Nebraska. Our J & C Taylor 8860(DUR,OKL) seems to be the third known collection for Wyoming and the first since 1910, when it was collected by Aven Nelson(RM). This species has been reported to Texas by Munz (1968), but a specimen validation is not known.

2. EUTHAMIA LEPTOCEPHALA Torry & Gray

This species with pedunculate heads is very similar in habit and occurs in the same habitat as the southern forms of E. gymnospermoides and they frequently grow intermingled where their ranges overlap in east Texas and southeastern Oklahoma. Distribution mapped by Sieren (1970) included Arkansas, southeastern Missouri, eastern Texas, Louisiana, and Mississippi. It is also known from the following states:

ALABAMA: CRENSHAW: Dozier, C. T. Reed B176(SMU); SUMTER: near Sumpterville, 2.5 mi off Hy. 11, Whitehouse 24394(SMU); TUSCALOSSA: By U S Hy. 43 above Grants Creek about 20 mi northeast of Eutaw, Kral 29449 (SMU).

OKLAHOMA: CHOCTAW: at Unger between U S Hy. 70 and the railroad track, J & C Taylor 9416(DUR,OKL).

3. EUTHAMIA TENUIFOLIA (Pursh) Nuttall

Plants of the pine forests along the coastal plain from Maine south to Georgia, Florida, and westward to Louisiana east of the Mississippi River. Sieren (1970) reports no specimens inland from the coastal states. The following specimens document its presence in the Great Lakes region:

INDIANA: JASPER: interdunal flat 1.5 mi south of Road 10, first road west of county line, Friesner 22968(SMU); PORTER: Baileytown, Bennett Aug. 17, 1958(SMU).

MICHIGAN: ALLEGAN: dried-up lake bed, S½. Sec 24, Clyde Tp., about 5.5 mi southeast of Fennville, Voss 8167(SMU) and Sec 27, shore of Lake Ely, Voss 8180(SMU); BARRY: small lake, NW¼, Sec 1, Orangeville Tp., about 5 mi northeast of Orangeville, Voss 8200(SMU); NEWAYGO: sandy mucky shoreline of Diamond Lake about 5 mi northwest of White Cloud, Voss 2880(SMU).

Sieren (1970) considered Euthamia remota Greene (Pittonia 5: 78, 1902) as a synonym of E. gymnospermoides. Greene's original description reads "rolling prairie country about Lake Michigan, not rare from northern Indiana to southern Wisconsin." and "where it has always passed for Solidago tenuifolia Pursh." He designated no type specimen for this name. The description of pedunculate heads and narrow leaves leads one to assume that Greene is referring to E. gymnospermoides which grows in the Great Lakes Region. However, Greene's reference to the fascicled leaves, and the maintenance of a primary stem with secondary branches less robust most aptly describes the distinguishing characters of E. tenuifolia, which closely resembles E. gymnospermoides. Thus the presence of populations in the Great Lakes region coupled with Greene's original description, _E. remota_ must be considered as a synonym of _E. tenuifolia_ rather than _E. gymnospermoides_.

4. _EUTHAMIA GALETORUM_ Greene

Known from Nova Scotia

5. _EUTHAMIA GYMNOSPERMOIDES_ Greene

Geographical distribution given in Figure 1.

6. _EUTHAMIA GRAMINIFOLIA_ (L.) Nuttall

Composed of three recognized varieties. The glabrous variety _graminifolia_ and the hirsute variety _Nuttallii_, according to Sieren (1970), both grow in the same areas with numerous intermediates. The shorter, more lanceolate-leaved forms from scattered locations in the western Rocky Mountains and central Canada are called variety _major_. My own collections from Canada indicate many late growing or diminutive forms may be keyed to this variety, and perhaps this form is not distinguished by a slightly different frequency of various characters in its gene pool. Sieren (1970) refers specimens from Virginia and North Carolina to _Euthamia hirtipes_ (Fernald) Sieren. After examining duplicate specimens at SMU of collections cited by Sieren, and after my own field investigations of this plant growing in Mississippi and Alabama, I do not believe the southern coastal plants are separate. The wide morphological amplitude of _E. graminifolia_ readily encompasses these plants. Based on specimen dates and manual citations, it seems to be recently introduced into the coastal area. The following collections supplement the geographical distribution mapped by Sieren (1970):

ALABAMA: MOBILE: Pine woods, Dauphin Island, J & C Taylor 15383(DUR).

MISSISSIPPI: HARRISON: north of Gulfport, 1 block south of the junction of Interstate-10 and Hy 49, J & C Taylor 13585(DUR).

MISSOURI: ATCHISON: prairies, Bush 11984(MO); CLARK: prairie 2 mi north of Peaksville, Droset, Sept. 26, 1934(MO); HENRY: between Lewis and Clinton, Steyermark 15931(MO); JACKSON: Bush, Sept. 3, 1888(MO); MORGAN: prairie west of Versailles, Steyermark 20341(MO); SCHUYLER: prairie 2 mi south of Queens City, Steyermark 16171(MO); SULLIVAN: between Harris & Osgood, Steyermark 16135(MO).

LITERATURE CITED

Anderson, L. E. 1954. Hoyer's Solution as a rapid permanent mounting medium for Bryophytes. Bryologist 57: 242-244.

Beaudry, J. R. & D. L. Chabot. 1959. Studies on Solidago L. IV The chromosome numbers of certain taxa of the genus Solidago. Canad. Jour. Bot. 37: 209-228.

Benson, L. 1962. Plant Taxonomy. Ronald Press Company, New York.

Britton, N. L. & A. Brown. 1913. Illustrated Flora of the Northern States and Canada. 2nd. Ed., revised. The New York Botanical Garden, New York.

Bush, B. F. 1918. The genus Euthamia in Missouri. Amer. Mid. Nat. 5: 157-177.

Correll, D. S. & M. C. Johnston. 1970. Manual of the Vascular Plants of Texas. Texas Research Foundation, Renner, Texas.

Coulter, J. M. & A. Nelson. 1909. New Manual of the Central Rocky Mountains. American Book Company, New York. p. 507.

Croat, T. B. 1970. Studies in Solidago 1. The Solidago graminifolia-S. gymnospermoides complex. Ann. Mo. Bot. Gard. 57: 250-251.

Fernald, M. L. 1908. Notes on some plants of northeastern America. Rhodora 10: 92-93.

_______. 1915. Some new or unrecorded Compositae cheifly of north-eastern America. Rhodora 17: 12-13.

_______. 1937. Plants of the inner coastal plain of Virginia. Rhodora 39: 456.

_______. 1946. Technical studies on North American plants. Rhodora 48: 65.

_______. 1950. Gray's Manual of Botany, 8th Ed. American Book Company, Chicago.

Friesner, R. 1933. The genus Solidago in northeastern North America. Butler Univ. Bot. Studies 3: 61.

_______. 1940. Some necessary nomenclatural changes in the genus *Solidago*. Butler Univ. Bot. Studies 4: 196.

Greene, E. L. 1902. A study of *Euthamia*. Pittonia 5: 72-80.

Harris, S. K. 1943. Notes on *Solidago*, section Euthamia. Rhodora 45: 413.

Kapoor, B. M. & J. R. Beaudry. 1966. Studies VII. The taxonomic status of the taxa *Brachychaeta*, *Brintonia*, *Chrysoma*, *Euthamia*, *Oligoneuron*, and *Petrodoria* in relation to *Solidago*. Canad. Jour. Genet. and Cyto. 8: 422.

Kuchler, A. W. 1964. Potential Natural Vegetation of the Conterminous United States. Amer. Geogr. Soc. Spec. Publ. No. 36. 116p.-map.

Mohldenbrock, R. H. and J. W. Voigt. 1959. Flora Southern Illinois. Southern Illinois University Press, Carbondale. pp. 359-361.

Munz, P. A. 1959. A California Flora. University of California Press, Berkeley.

Nuttall, T. 1818. Genera of North American Species. D. Heartt, Philadelphia. p. 172.

Percival, M. S. 1965. Floral Biology. Pergamon Press, New York. p. 155.

Rosendahl, C. O. & A. Cronquist. 1945. The goldenrods of Minnesota: a floristic study. Amer. Midl. Nat. 33: 244-253.

Rydburg, P. A. 1931. Taxonomic notes on the flora of the prairies and plains of central North America. Brittonia 1:102.

Shinners, L. H. 1951. The Texas species of *Euthamia* (Compositae). Field & Lab. 19: 137-138.

Sieren, D. J. 1970. A taxonomic revision of the genus *Euthamia*. Ph.D. Dissertation, University of Illinois, Urbana.

Small, J. K. 1933. Manual of the Southeastern Flora. Published by the author, New York.

Steyermark, J. A. 1963. Flora of Missouri. Iowa State University Press, Ames.

Taylor, R. J. 1967. The relation of forest vegetation and geology in the Gulf Coastal Plain in Oklahoma. Ph.D. Dissertation, University of Oklahoma, Norman.

Torrey, J. & A. Gray. 1842. Flora of North America, Vol. ii. pp 190-227.