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(LEGUMINOSAE).

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**REVISION OF THE GENUS PETALOSTEMON
(LEGUMINOSAE)**

by

Don Kimberly Wemple

**A Dissertation Submitted to the
Graduate Faculty in Partial Fulfillment of
The Requirements for the Degree of
DOCTOR OF PHILOSOPHY**

Major Subject: Systematic Botany

Approved:

Signature was redacted for privacy.

In Charge of Major Work

Signature was redacted for privacy.

Head of Major Department

Signature was redacted for privacy.

Dean of Graduate College

**Iowa State University
Of Science and Technology
Ames, Iowa**

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INTRODUCTION

Petalostemon as herein delimited comprises 29 species of North American papilionoid legumes of the tribe Psoraleae (Rydberg 1928a, 1928b; Isely 1958, 1962; Lersten and Wemple to be published)¹. The genus is distinguished from other members of the tribe by the possession of both of two basic characters: 1.) there are only five stamens; 2.) the four petals other than the standard are inserted at the apex of the staminal tube and alternate with the filaments, while the standard is inserted at the floral base.

The original objective of this investigation was the delimitation of the taxa within Petalostemon. However, it was soon evident that a reconsideration of the generic limits of Petalostemon was desirable if not essential. A considerable proportion of the research efforts herein reported were, therefore, directed towards the latter end; particularly the interrelationships of Petalostemon and Dalea. Both phases of these investigations are presented in this paper.

¹The most recent worldwide treatment of the Leguminosae (Hutchinson 1964) divides the Psoraleae into two tribes, Daleae and Psoraleae. Petalostemon and its close relative Dalea are placed in the former tribe. Evidence contrary to Hutchinson's division is presented by Lersten and Wemple (to be published).

METHODS AND MATERIALS

Field collections and observations

Field studies of Petalostemon were conducted during the growing seasons 1961-1964 inclusive. All species of the genus were observed in situ except those few indigenous to the Great Basin and the Pacific Northwest. In addition to insight into the distribution, breeding mechanisms and ecological relationships of the species, living material was collected and placed in the greenhouse for additional study.

Greenhouse cultivation

Plants were grown from both rootstocks and seeds. The rootstocks were collected in the field; after removal of the tops they were transported to the greenhouse in polyethylene bags. The potting medium was Iowa prairie soil with approximately 25% coarse river sand added to facilitate drainage.

Following threshing and scarification, seeds were germinated on moistened blotter paper in Petri dishes placed in a 20° constant temperature chamber in the Iowa State University Seed Laboratory. When seedlings were 1--2 cm long they were transferred to five inch pots, approximately five seedlings per pot. No further transfers were necessary. Voucher specimens of all plants cultured were deposited in ISC.

Hybridization studies

A program of controlled cross pollinations in the greenhouse was initiated in an attempt to elucidate genetic relationships within the genus. Since most species of Petalostemon are obligately entomophilous, there is no self fertilization in an insect free greenhouse; therefore, the common practices of "bagging" and emasculation are unnecessary. Pollination was carried out by using a stamen as a pollen applicator -- merely touching it to the stigmas of the female parent. Complete pollination of a spike usually took about two weeks because the flowers open sequentially.

In the field, fruits are presumably shaken from the rachis by wind and rain action. Lacking this dispersal force in the greenhouse, the fruits remain attached to the rachis and can conveniently be collected when the seeds of a whole spike mature. The resulting seeds were germinated in the same manner as those collected in the field.

Cytological studies and pollen analysis

Cytological material was obtained in part from germinated seeds. Root tips were cut off when they attained a length of 1--2 cm and immediately placed in a one-fourth strength nutrient solution (Hoagland and Arnon 1950) with 0.02 percent actidione, a mitotic inhibitor. After 7--8 hours treatment they were fixed in 3:1 alcohol-acetic acid for twenty four hours. The root tips were then hydrolyzed for 8--9 minutes in

1 Normal HCl at 60° and placed in Feulgen stain for 45--70 minutes. Following "squashing," the slides were made permanent by the liquid CO₂ freezing technique (Bowen 1956).

Meiotic counts were obtained from buds collected in the field as well as the greenhouse. Fixation was by 3:1 alcohol-acetic acid and the preferred stain was propiocarmine. All cytological illustrations were made using the Zeiss Drawing Attachment. Voucher specimens of all plants from which successful counts were obtained were deposited in ISC.

Pollen was collected from living plants, both in the field and the greenhouse, as well as from herbarium specimens. Semi-permanent slides were prepared using lactophenol-cotton blue (Sass 1958; Stone 1963) as a combination stain and mounting medium. Fresh pollen can be studied within a few hours; samples from herbarium specimens require 24 hours to allow the stain to penetrate and inflate the dehydrated grains. Length, width and stainability were recorded. The latter characteristic is an approximation of viability of fresh pollen. From each sample ten lengths and widths were measured using an ocular micrometer at 430x magnification. Each species was sampled at least twice. An average length and width was calculated for each pollen sample as well as an average for all samples from a given species. Range, arithmetic mean and standard deviation were calculated. A record was kept of the percentage of blue-staining grains in each sample.

Herbarium study

Over 4,000 herbarium specimens were studied during the course of this investigation. I should like to express my appreciation to the curators of the following institutions who made them available. Those herbaria denoted by an asterisk supplied type material only. Abbreviations used for all herbaria cited in this paper are those of Lanjouw and Stafleu (1964).

- *B Botanisches Museum (Germany)
- D Duke University
- *F Chicago Natural History Museum
- FLAS University of Florida
- FSU Florida State University
- *G Conservatoire et Jardin botaniques
 (Switzerland)
- GA University of Georgia
- *GH Gray Herbarium of Harvard University
- *GL University of Glasgow (Great Britain)
- ISC Iowa State University
- *KANU University of Kansas
- KY University of Kentucky
- MO Missouri Botanical Garden
- NO Tulane University
- NY New York Botanical Garden
- OKLA Oklahoma State University
- *P Muséum National d'Histoire Naturelle
 Laboratoire de Phanérogamie (France)

- *PH Philadelphia Academy of Natural Sciences
- RM Rocky Mountain Herbarium
- SMU Southern Methodist University
- TENN University of Tennessee
- TEX University of Texas
- *UC University of California, Berkeley
- US United States National Herbarium
- *WS Washington State University

Synonyms for each species are listed in the taxonomic treatment. The procedure of Isely (1962) is used to indicate the basis for inclusion of each name as follows:

- (1) Type specimen or photograph of same examined.
- (2) Original description examined.
- (3) Name utilization follows that of another author who has examined an original specimen or type.
- (4) Name utilization follows that currently accepted; typification not verified.

Multiple designations, e.g. (1)(2), indicate congruity between the sources of information indicated. The appropriate number(s) follows the citation of each name.

The distributional maps are based on specimens studied by the author. The specimens are cited in the appendix. Only representative specimens (one from each county) of the wider ranging or more common species are cited. Those of the less frequently collected or local species are all cited.

Clearing techniques

The vascular anatomy of the flowers of Petalostemon and related genera was studied by means of clearings (Brady, Wemple and Lersten 1964). Herbarium specimens were the major source of material, supplemented by fresh flowers killed and fixed in FAA or CRAF III (Sass 1958). They were cleared in 5% NaOH and chloral hydrate, stained with safranin and mounted in Piccolyte. Clearing without staining, using Hoyer's Solution (Anderson 1954) was found to be a valuable and timesaving technique. Permanent slides were made directly from dissected specimens, softened in a wetting agent (Pohl 1954), and without resorting to tedious dehydration, mounted in Hoyer's Solution.

Certain aspects of anatomy not clearly observable by clearing techniques were studied by means of microtome sections. These were prepared and stained by conventional methods (Sass 1958).

HISTORICAL REVIEW

The first specimen of Petalostemon returned to the Old World was collected by Walter. A description was included in his Flora Caroliniana (1788) as "Anonymos Kuhnia affinis. pinnat." It is the plant we now know as Petalostemon caroliniense. The following year (1789), Lamarck provided Walter's specimen with a conventional binomial, Kuhnistera caroliniensis. Both Walter and Lamarck considered the plant a composite.

In the same year as Lamarck's publication, A. de Jussieu, in Genera Plantarum (1789) seems to have included the Walter species within Dalea -- a resurrection of the name used by Linnaeus in the first edition of Genera Plantarum (1737) but subsequently dropped. Although not mentioning the Walter specimen by name, Jussieu (p. 355) follows the description of Dalea with:

Speciem habeo siccam, habitu flosculosam Eupatorii instar sed Daleae ferè congenerem cui calix communis polyphyllus inbricatus multiflorus, calix proprius inferus 5-partitus plumosus, petala 5 subaequalia unguiculata, caetera similia.

Ten years later (1799a), "Tableau du regne Vegetal, selon la methode de Jussieu" by E. P. Ventenat appeared. He corroborated the fact that Jussieu was indeed speaking of Walter's plant (p. 395).

La plante dont Jussieu donne une courte description après avoir exposé les caractères du Dalea, est, selon Michaux, L'Anonymos de Walter.

Ventenat then clearly set forth the differences between this specimen and other species of Dalea concluding by maintaining the Lamarck genus Kuhnistera as separate from Dalea. He included under the latter genus both 5 and 10 staminate species, thus amending Jussieu's original concept of the genus. Although Ventenat cited no species per se, his description of a representative Dalea is clearly that of D. purpurea, a species that he eventually named in 1800.

Ventenat's previously stated views were expanded in Dissertation sur le Genre Dalea (1799b), recognizing as distinct genera, Dalea and Kuhnistera, but again presenting no species names. The following year (1800) his description of Dalea purpurea appeared. This species, now Petalostemon purpureum (Vent.) Rydb., was described as one of a number of "rare and unusual" plants growing in the gardens of J. M. Cels in Paris. The seeds of this species were apparently collected in Illinois by Michaux several years before and passed into the hands of J. M. Cels.

The year 1803 saw the publication of Michaux' Flora Boreali-Americana. In it, Kuhnistera was considered akin to the pentastaminate members of Dalea and both were included in the new genus Petalostemum. Michaux, or L. C. Richard who wrote the diagnoses for the Flora (Barneby 1965), chose to

ignore Lamarck's specific epithet (caroliniensis) for Walter's specimen, although Lamarck's generic name, Kuhnistera, was cited in synonymy. The species was called Petalostemum corymbosum. Other species named were P. candidum, P. carneum and P. violaceum. The latter falls within the circumscription of Dalea purpurea, but Ventenat was not cited.

Prior to the publication of the Flora Boreali-Americana, Willdenow's third volume of Species Plantarum was issued (1802, according to Schubert 1942). Willdenow recognized both five and ten staminate species in the genus Dalea, enumerating three with five stamens, D. candida (citing P. candidum Michx.), D. violacea (citing P. violaceum Michx.) and D. kuhnistera (citing Lamarck as well as Walter).

Poiret (1804) included all the aforementioned species with the ten-staminate Daleas in the genus Psoralea, a treatment similar to the later works of Linnaeus. Subsequently, in Dictionnaire des Sciences Naturelles (1818) he again rejected the idea of separate generic ranking for the pentastaminate species (p. 459).

Le genre Petalostemum de Michaux ne peut être séparé des dalea, quoique ses fleurs ne renferment souvent que cinq étamines, seul caractère qui le distingue. He recognized D. purpurea, D. carnea, D. candida and D. corymbosa.

In summary: as of 1818, the species of the taxon herein

called Petalostemon, had been placed under four different generic names, Kuhnistera, Petalostemon, Dalea and Psoralea. No subsequent authors have included the species as a part of Psoralea; that genus was later more precisely defined to exclude those species possessing only one flower per subtending bract, pinnate leaves composed of more than three leaflets and petals inserted anywhere other than at the floral base. With the exception of Shinnars (1949), no authors have included the species of Petalostemon within Dalea (although Barneby (1965) strongly argues for their merger). Rather, Dalea has been limited to species possessing (7) 9--10 stamens, a more or less papilionoid corolla and petals inserted either at the floral base or part way up on the androecial tube -- a definition more in line with that of Michaux than that of Jussieu. Barneby (1965), in fact, recommended conservation of Dalea, sensu L. C. Richard in Michx. over other definitions of the genus. Petalostemon was adopted for all the pentastaminate species by most authors, e.g. Pursh (1814), Candolle (1825), Don (1832), Torrey and Gray (1838) and Endlicher (1840) among classical treatments. Others maintained both Petalostemon and Kuhnistera as separate genera, e.g. Bartling (1830) and Lindley (1853) -- a practice continued into the twentieth century by Small (1903, 1933), Rydberg (1919-1920) and most recently, Hutchinson (1964).

Kuntze (1891) revived Kuhnistera in place of Petalostemon based on its prior publication, and made new combinations for

the nineteen species known at that time. As one of the adherents to the American code which adopted Kuhnistera, A. A. Heller published "Notes on Kuhnistera" (1896), a definitive work at that time. It included twenty two species with critical synonymy and nomenclatural notes. The next complete treatment of the genus was by Rydberg (1919-1920), who, as above indicated, separated Petalostemon from Kuhnistera including forty two species in the former and two in the latter. This was the last complete summary of the genus to this date although Isely (1958) in a generic summary of the tribe Psoraleae reconsidered the problems in the delimitation of the genus. Since the conservation of Petalostemon over Kuhnistera (Briquet 1912), all authors have employed Petalostemon, at least for the species other than P. caroliniense and P. adenopodum. Kuhnistera has been maintained as a separate genus by Rydberg (1919-1920), Small (1903, 1933) and Hutchinson (1964) as previously stated. Isely (1958) as well as authors of two recent Carolina floras, Wilbur (1963) and Radford, Ahles and Bell (1964), unite all species under Petalostemon.

There has been controversy over alternative spellings of the noun Petalostemon as well as interpretation of gender (masculine or neuter). Michaux originally used the spelling Petalostemum in conjunction with neuter specific epithets. Most authors since the original publication have used Petalostemon, some considering it masculine, others neuter.

Rydberg (1919-1920) comments in a footnote, "Originally published as Petalostemum, but incorrect as στημων is masculine and has a long 0 in the final syllable." Shinnars (1949, p. 81) employed Michaux' original spelling and adds a footnote:

In the list of nomina conservanda making up Appendix III of the International Rules of Botanical Nomenclature (cf. Brittonia 6: 67, 1947), this is altered to the etymologically proper form of Petalostemon -- in flagrant violation of Article 59 of the same Rules, expressly forbidding such corrections!

I have herein adopted both the spelling and gender indicated by the Nomina Generica Conservanda in the citation of the generic type, Petalostemon candidum.

DELIMITATION AND VALIDITY OF PETALOSTEMON

As pointed out by Isely (1958), the validity of the genus Petalostemon rests on an understanding of the floral morphology of both Petalostemon and Dalea. Since no acceptable morphological interpretation has yet been made, taxonomic viewpoints have been less than unanimous. Michaux (1803) almost certainly interpreted the petals as staminodes, hence the implication of his name, "petal-stamen." On the basis of an anatomical study, Moore (1936) offered evidence supporting the hypothesis that all five of the Petalostemon "petals" are staminodes. His conclusions were based on the vascular pattern of the floral receptacle, as reconstructed from serial microtome sections of Petalostemon candidum. He also cleared flowers of this species by boiling them in concentrated lactic acid. Isely (1958, 1962) accepted Moore's interpretation with some reservations as did Turner (1959). Gleason (1952) and Porter (1957), on the other hand, accepted only the four apical appendages as staminodes and interpreted the standard as the only remnant of the true corolla. Neither Gleason nor Porter referred to Moore's work. These various floral interpretations have obscured the true relationship of Petalostemon to the large genus Dalea, to which it is certainly closely allied.

Petalostemon can usually be distinguished from Dalea by two basic characters: 1.) there are only five stamens; 2.)

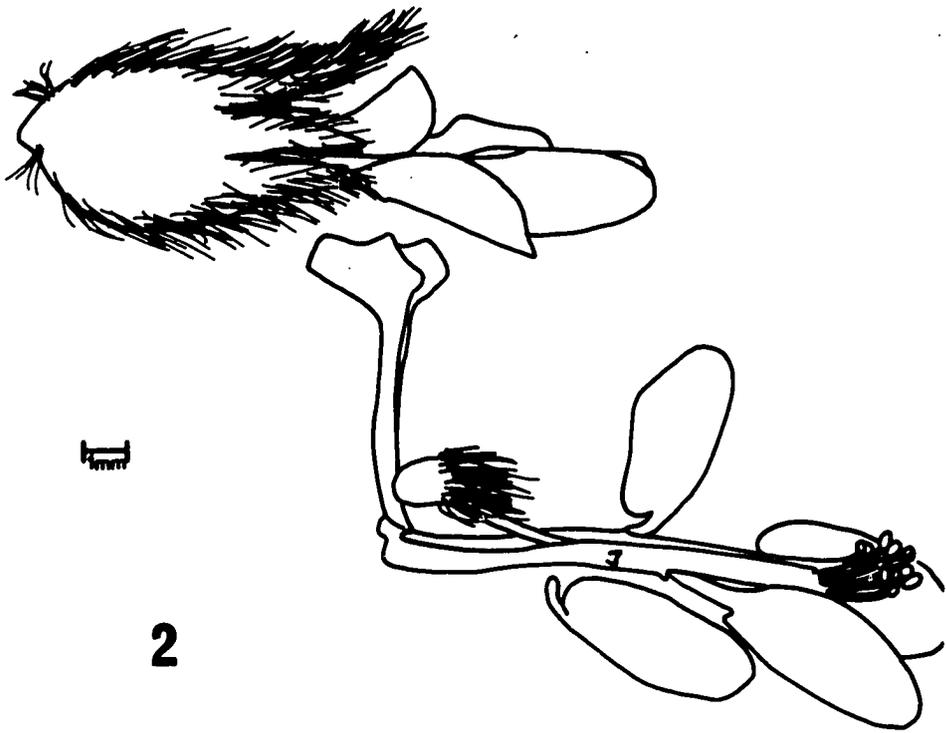
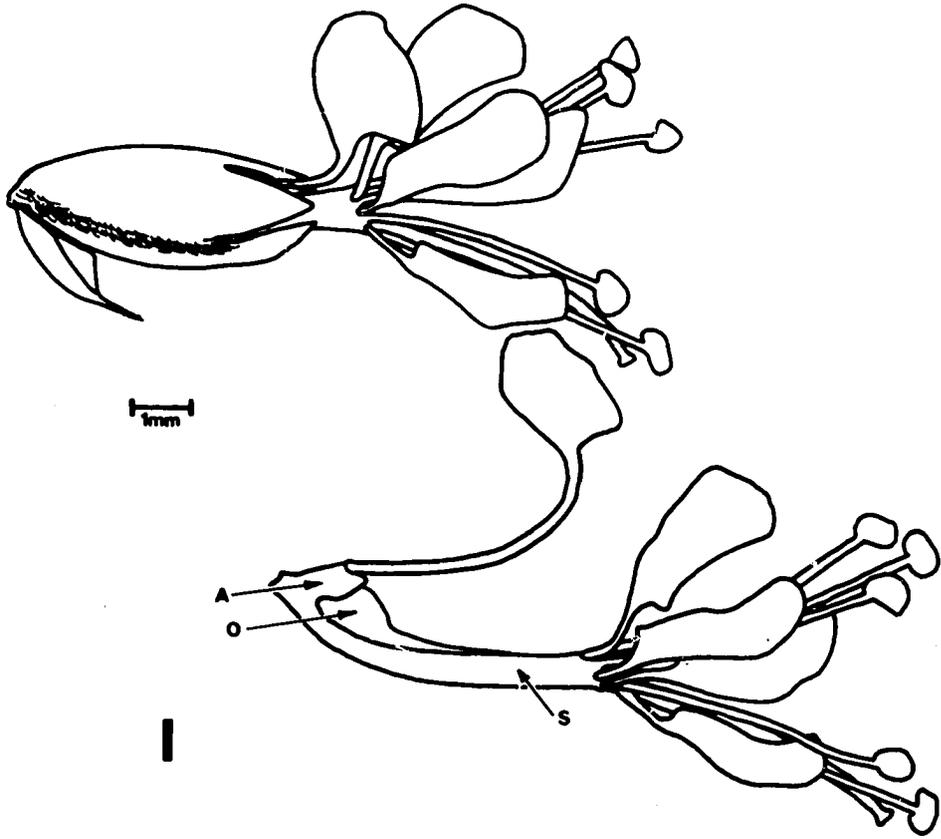
the four petals other than the standard are inserted at the apex of the staminal tube alternating with the filaments (Fig. 1).

Most species of Dalea have nine or ten stamens and nearly all have a distinctly papilionoid corolla. In some species all five petals are inserted on the hypanthium below the staminal tube. More commonly the wing and keel petals are attached at some point on the staminal tube (Fig. 2). In some species, however, the four anterior petals are inserted almost at the apex of the staminal tube, approximating, but not quite attaining, the Petalostemon condition. This is found in Rydberg's segregate genus Thornbera (Rydberg 1919-1920), a part of Dalea in the broad sense. In gross appearance certain species of Dalea and Petalostemon are easily confused. An additional taxonomic separation of the two genera has been based on petal claw length (Rydberg 1919-1920; Wiggins 1940), however, Shinnars (1949) demonstrated that this character was not consistent in all species and partially on this basis included the Texas species of Petalostemon in Dalea.

The question of whether the petals are true petals or staminodes is a critical one in understanding the relationship between Dalea and Petalostemon and a reappraisal of certain aspects of floral morphology of Petalostemon was undertaken with special regard to the questions of petal origin, petal insertion and stamen number.

Fig. 1. Petalostemon pulcherrimum. Above, entire flower with subtending bract. Below, flower with calyx removed. O, ovary; S, staminal tube; A, "apron"

Fig. 2. Dalea aurea. Above, entire flower. Below, flower with calyx removed, keel petals spread and one wing petal disarticulated from its socket on the staminal tube. The standard is elevated and the carpel raised to show their relationship



2

The nature of the corolla

Clearings, whole mounts and serial sections of the apex of the staminal tube of Petalostemon show clearly that each apical petal has its own articulation socket (Fig. 3, 4). A socket is found at the base of the standard also (Fig. 5, 6). The claw of each petal tapers down to a blunt point and inserts into the flanged socket of the tube. The claw is tenuously attached by the vascular bundle and one or two layers of small cells. The entire structure is apparently an adaptation for petal abscission. Similar structures are not uncommon among other angiosperms (Pfeiffer 1928; Sharsmith 1961).

The filaments arise smoothly from the staminal tube with no indication of even a constriction, much less a specialized socket (Fig. 3). If one is to assume that the petals are in reality staminodes, it is then necessary to presume modifications resulting not only in filament flattening but also in socket formation at the base of the sterile stamens.

The apical petals of Petalostemon are frequently described as bilaterally symmetrical. They are not. This is particularly evident in P. pulcherrimum (Fig. 13). The laminae of the lateral petals are quite asymmetric and the claws are offset to one side. The venation pattern also varies. While one of the side veins extends into the major part of the lamina in the lateral petals, it is the center vein that supplies most of the lamina in the medial petals. Although the

- Fig. 3. Tangential section of the apex of the staminal tube of Petalostemon occidentale. A petal claw in its socket is central, flanked by filaments which are continuous with the tube.
- Fig. 4. Clearing of the apex of the staminal tube of P. candidum. The petal claw has been removed but the socket is clearly seen flanked by two filaments
- Fig. 5. Clearing of the dorsal portion of carpel and apron with attached standard claw of P. pulcherrimum. Arrow indicates socket and union of claw and apron
- Fig. 6. Transverse section through the base of the flower of P. occidentale. The carpel is surrounded by the staminal tube below and the apron above. The attachment of the standard claw is indicated by the arrow
- Fig. 7. Clearing of the floral base of P. occidentale showing the pedicel traces radiating out as calyx bundles (C), and the gynoecial bundles (G), coalescing into the discontinuity plate
- Fig. 8, 9. Clearings of the floral base of P. tenuifolium. Fig. 8 with the discontinuity plate in focus and Fig. 9 with the plate below the field of focus but with the androecial bundles sharply in focus. A, androecial bundles; S, standard bundle
- Fig. 10. Radial section of the staminal tube of Dalea aurea showing a petal claw in a socket on the side of the tube
- Fig. 11. Clearing of the staminal tube apex of Petalostemon emarginatum. The upper arrow indicates the apex of the tube, the lower, the position of the socket
- Fig. 12. Clearing of the staminal tube of Dalea gigantea. The arrow indicates the position of a socket



petals are not papilionoid-shaped wings and keels, there is a dimorphism between lateral and medial petals that is consistent within a species.

At the base of the flower, in the area of the receptacle, is the "discontinuity plate" (Brady, Wemple & Lersten 1964). As in the species of Dalea examined, the plate is the result of a merging of the gynoeceal traces at the base of the carpel and the horizontal proliferation of the associated tracheoidal cells (Fig. 7, 8). The xylem of the carpel is not connected to the xylem of the pedicel. Another xylem discontinuity is found between the petal and stamen bundles and the rest of the floral vasculature. The bundles from the apical petals and stamens pass down the tube but the xylem ends abruptly just short of, but lateral to, the discontinuity plate. The xylem of the standard bundle has a similar ending (Fig. 8, 9). These discontinuities are consistent and predictable in all species of Petalostemon and Dalea examined and differ among species only in size and shape of the discontinuity plate. In all cases the plate is mature prior to anthesis and shows little or no further development between anthesis and mature fruit. Discontinuities and discontinuity plates appear to be definitive floral characteristics of all members of the tribe Psoraleae (Lersten & Wemple to be published).

Three theories concerning the nature of the corolla in Petalostemon may be considered:

1. a. Five stamens are modified to staminodes.
- b. The standard is also a staminode.
- c. There is a complete loss of all petals as well as their traces in the receptacle.
2. a. Four stamens are modified to staminodes.
- b. The standard is the only remnant of the corolla.
- c. There is a complete loss of wing and keel petals as well as their traces in the receptacle.
3. a. The four petals attached to the apex of the androecial tube are true petals.
- b. The standard is an unmodified papilionoid standard.
- c. There is a complete loss of one whorl of stamens and their traces.

The first alternative is unlikely because the standard has the shape and insertion typical of that in most papilionoid flowers and in addition encloses the other petals and stamens in the bud, another characteristic of a "good" standard. A further argument against this theory is that to suggest that the standard is a staminode would indicate a derivation from a diadelphous condition. Dalea, admittedly has a true corolla and is monadelphous with either nine or ten stamens. If the hypothesis of staminodial origin is to be considered in Petalostemon, it is more plausible for the apical structures than for the standard.

The second theory, that only the apical petals are staminodes, also seems unlikely because of the possession by the petals (but not the filaments) of articulation sockets.

Similar sockets are found in those species of Dalea in which the wing and keel petals are inserted on the staminal tube (Fig. 10, 12). There is also a socket at the base of the standard in Petalostemon indicating homology with the apical petals. In some species of Petalostemon there is dimorphism between the lateral and medial apical petals; this is additional evidence for the rejection of the second hypothesis.

Moore's (1936) interpretation of the flower of Petalostemon seems to lack validity; for example, his statement (p. 287), "The sterile members of the androecium alternate with the calyx lobes and thus seem to be the outer members of the stamen whorl," is perplexing. From his preceding discussion it would seem that petal traces and the traces of the inner whorl of stamens would alternate with calyx lobe traces. The outer whorl of stamen traces would be on the same radii as the calyx lobe traces. In response to a second point, "The stamen traces are cast off in two alternating sets," it is apparent from whole mount clearings and serial sections that Moore could not possibly have seen these traces departing from the stele because the xylem is completely discontinuous in this area. In serial sections through the Petalostemon discontinuity area, interpretation of vascular structure is almost impossible. Without knowledge gained from whole flower clearing one would most certainly have been inclined to disregard these sections as artifacts. It is possible that Moore did just that and then, relying on his observations in other

papilionoid genera, extrapolated to the vascular anatomy of Petalostemon, fitting them into his preconceived idea of loss of petals and staminodial development in Petalostemon.

Barneby (pers. comm. 1964) has pointed out that if the petal claws in Dalea and Petalostemon are really fused to the androecial tube then articulation sockets have developed in the claws themselves -- an "unprecedented development in the legumes." An alternative explanation is that the part of the tube below the petal sockets is in reality an asymmetrically developed hypanthial ring. When the petals are all inserted at the base of the calyx, as they are in many species of Dalea, they seem clearly to arise from an hypanthium. When wing and keel petals are inserted a short way up the tube it is not difficult to imagine that one side of the ring (the side opposite the standard) is extended upward. When the extreme stage is reached, as in Petalostemon, in which the petals are inserted a great distance from the floral base, the hypothesis of hypanthial extension possibly seems fantastic but every stage between the two extremes is evident. Further support for the hypothesis of hypanthial extension is that in all species of Petalostemon examined, the standard does not insert at the very base of the flower but arises from a socket on the "apron" (Fig. 1, A). The tissue of the apron is continuous with that of the staminal tube, and it could possibly represent the dorsal development of the asymmetrical hypanthial ring and the androecial tube the ventral.

A condition of petal insertion similar to that found in Petalostemon has been reported in Hesperolinon (Linaceae). Sharsmith (1961), in her monograph of the genus, also invoked the hypothesis of hypanthial extension.

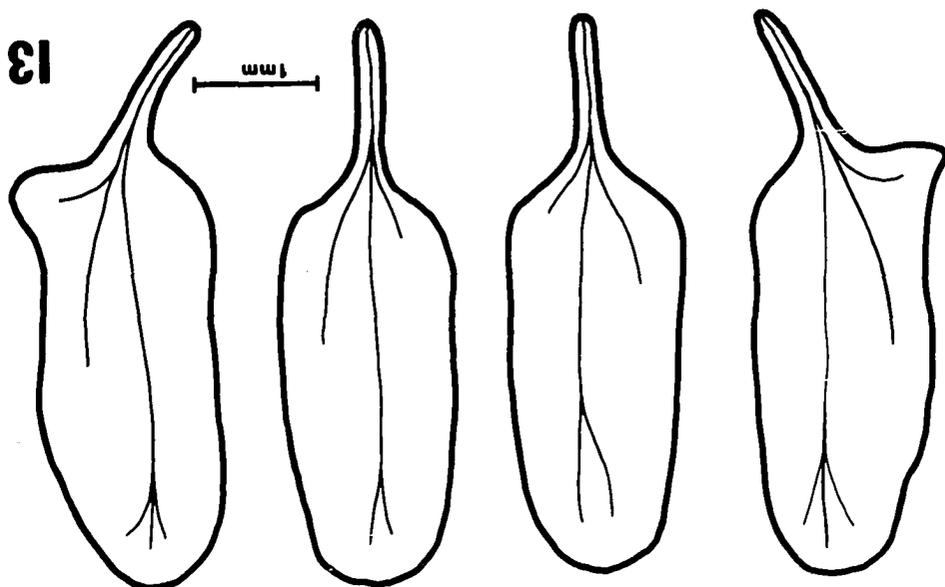
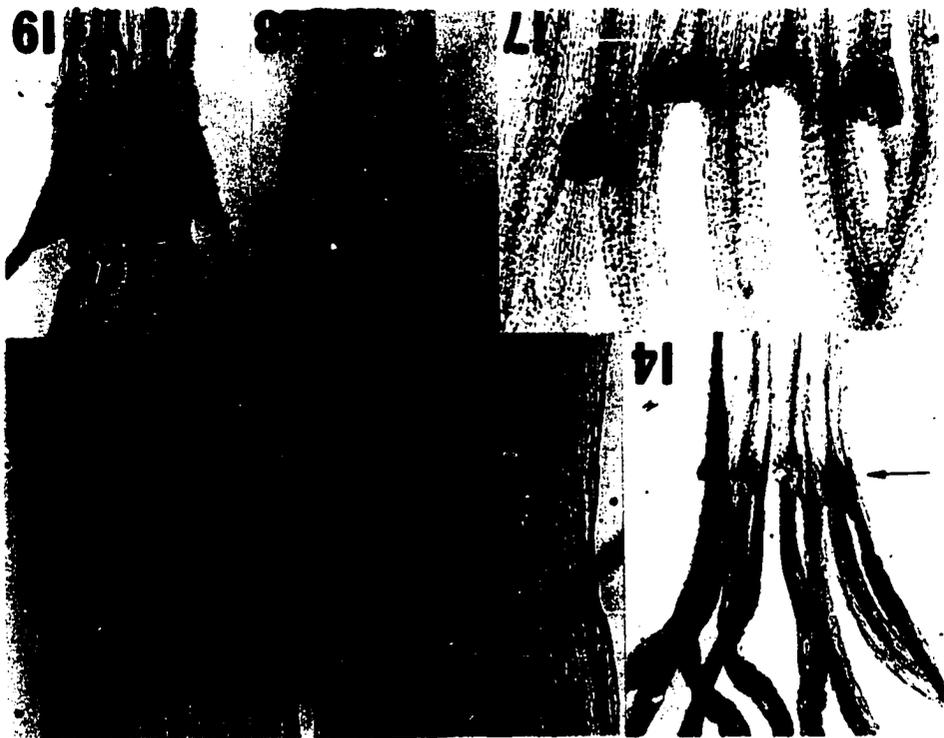
Variations in petal placement and stamen number

Dalea has traditionally been separated from Petalostemon because it usually has nine or ten stamens; the petals are not inserted at the apex of the tube; and the keel petals are usually connate at their tips. Tendencies toward the Petalostemon morphological pattern, however, have been found in three separate sections of Dalea.

Among members of Rydberg's segregate genus, Thornbera, the petals are inserted very high on the androecial tube (Fig. 14). However, of the Thornbera species examined, none have the petals precisely at the apex and interdigitated with the filaments as in Petalostemon, and all have nine or ten stamens.

In another line of Dalea (sect. Polygonoides of Rydberg's genus Parosela) the petals are inserted at the middle of the tube or lower, but the stamen number varies. Close examination of D. polygonoides discloses flowers with as few as five stamens, but the numbers seven and eight are most common. In all flowers of this species, the staminal tubes have nine vascular bundles below the level of the sockets regardless of stamen number, but in flowers having seven or eight stamens,

- Fig. 13. Apical petals of Petalostemon pulcherrimum arranged in the same position as they are on the staminal tube
- Fig. 14. Apex of the staminal tube of Dalea cliffortiana. Socket level is indicated by the arrow
- Fig. 15. Tube apex of a 7-staminate Dalea polygonoides. Arrows indicate vascular bundles on the same radius continuing above two of the sockets
- Fig. 16. Tube apex of a 5-staminate Dalea polygonoides. None of the sockets have bundles on the same radius continuing above them
- Fig. 17. Tube apex of a 6-staminate Petalostemon obovatum. The auxilliary stamen filament is behind the socket on the right
- Fig. 18, 19. Tube apices of Petalostemon tripetalus. Petal sockets are seen at the bases of the micrographs. Arrows indicate "rudimentary" filaments



"double bundles" are present. Each double bundle consists of a petal and a filament trace on the same radius. Flowers with seven stamens have two double bundles and flowers with eight stamens have three double bundles. The outer trace of each double bundle supplies a petal and the inner continues above the level of the petal socket with the other bundles to the filaments (Fig. 15). In flowers with five stamens, all of the bundles are single -- there are nine bundles below the sockets and only five above (Fig. 16). The similarity here to the condition found in Petalostemon is obvious. In Petalostemon nine bundles traverse the entire length of the androecial tube, four supplying the petals through sockets at the apex and the remaining five supplying the filaments.

A third Dalea line showing Petalostemon-like characteristics is indicated by Barneby's account of a Dalea of subg. Trichopodium (Barneby pers. comm. 1964). This species has:

vegetative and calycine characters unquestionably of that group and therefore not at all suggestive of any known Petalostemon, but it is pentandrous and has four inner petals all separate and inserted close up to the point where the stamens come free from each other.

This very distinct undescribed species is technically a Petalostemon, but obviously a Dalea (and is sympatric, on the coast of Sonora, with decandrous Daleae similar in appearance).

Variation in stamen number and petal placement typical of

Dalea are also found in Petalostemon. One collection of Petalostemon obovatum (Wemple & Jackson, 724), endemic to southern Texas, has about 40% of its flowers with six stamens. The petals are inserted at the apex of the tube but one of the nine bundles of the tube is double and a filament arises from the outer surface of the tube behind a socket, one bundle passing into the petal, the other entering the filament (Fig. 17).

Two annual species, originally described as Petalostemon but herein excluded from this genus, were studied. P. tripetalus has but two or three subapical petals and normally five stamens. Between the "normal" five filaments are invariably found rudiments of filaments. Sometimes the latter consist of only "bumps" of tissue without vascular supply, but in other instances filaments develop to almost the same length as the alternating ones and have a visible xylem supply (Fig. 18, 19). The vascular bundles of the lower tube number eight in flowers with three anterior petals and seven in the flowers with two petals. Xylem vessels that pass into the "rudimentary" filaments arise de novo about two-thirds the distance up the tube. This was the only observation made of such a phenomenon. P. emarginatum has petals inserted below the apex of the tube (Fig. 11). P. tenuifolium, P. compactum, P. flavescens and P. ornatum also have the petals inserted slightly below the apex but not as far below as P. emarginatum. Although the first four species are clearly Petalostemon in

gross morphological aspects, P. emarginatum, an annual, is almost indistinguishable from many of the annual Daleas.

Conclusions

There is apparently no clearly defined disjunction between Petalostemon and Dalea, and evidence from vegetative anatomy and floral morphology indicate a common ancestry. A chromosome number of $n = 7$ is shared by both genera, also indicative of a close relationship. Notwithstanding the similarities between the two genera, Petalostemon represents a highly specialized branch within the heterogeneous daleoid complex. This specialization has resulted in both the loss of one whorl of stamens and the migration of four petals to the apex of the staminal tube. The species of Dalea possessing petalostemoid characteristics appear to arise from diverse sections of the genus and perhaps represent specialized and independent, albeit somewhat convergent evolutionary trends. A complete reassessment of the placement of Petalostemon must await revision of the remainder of the daleoid complex but it is feasible at present to redefine the generic delimitations of Petalostemon excluding all taxa possessing more than five stamens as well as those with petal insertions substantially below the apex of the staminal tube.

The reticulate, often convergent pathways taken by the evolutionary processes in many groups often makes generic lines somewhat indistinct. This is certainly true in many

groups of legumes and emphatically true in other plant families (e.g. Cruciferae, Gramineae). Therefore, at least more than one viewpoint of what constitutes generic delimitation in a particular taxon is admissible. The alternative to the present disposition of Petalostemon, as advocated by Shinnars (1949) and Barneby (1965) would be to reduce it to some sub-generic ranking within Dalea; but again, the same problems would be encountered only at a different taxonomic level. The acceptance of Petalostemon, as herein defined, seems to result in a reasonably natural genus of perennials, easily definable from the melange that is Dalea.

DELIMITATION OF SUBGENERIC TAXA

Two lines are evident within my delimitation of the genus Petalostemon. The first is represented by the species originally collected by Walter and herein called P. caroliniense. Michaux (1803), or L. C. Richard who wrote Michaux' diagnoses, was the first to unify Kuhnistera with what were considered the pentastaminate members of Dalea in the new genus Petalostemon, a position with which I concur. Rydberg, in the most recent revision of the Psoraleae (1919-1920), considered the differences shown by Kuhnistera to be sufficient to merit generic status. The basic characteristics used to substantiate separation of the Kuhnistera are: 1.) spikes disposed in a corymbose manner; 2.) sterile involucrel bracts subtending individual spikes; and 3.) plumose, filiform calyx lobes. I consider the three taxa composing Kuhnistera to belong within Petalostemon because all of the primary identifying characters of the latter genus are found, in addition to these specialized characteristics which seem merely exaggerations of those found in other species of Petalostemon. For example, Petalostemon multiflorum possesses an inflorescence with a somewhat corymbose structure. Sterile bracts subtending flower spikes are present in all of the southeastern species of Petalostemon as well as many other species throughout the range of the genus. None, however, exhibit the degree of bract expansion found in P. caroliniense. An approach to the

plumose-filiform lobes of P. caroliniense is found in P. ornatum of the Pacific Northwest. In short, the features characteristic of subgenus Kuhnistera are merely quantitatively but not qualitatively different from those of other species of the genus. With the above considerations in mind, I have adopted DeCandolle's (1825) viewpoint: one genus, Petalostemon, with two subgeneric categories.

Within subgenus Petalostemon certain groupings can be made based on morphological similarities. I have recognized these groups by using Rydberg's (1919-1920) technique of unofficial sectional names. It is clear from my work that at least some of these sections are more than mere phenotypic associations. The Purpurei, for example, are almost completely interfertile, whereas, hybridization between one of its members and another species outside the section is rare. The same is true of the Candidi. Although compatibility studies did not cover all species and sections it seems clear that morphologically based relationships have a sound genetic basis within this genus.

COMPATIBILITY STUDIES

During the fall of 1962, a program of controlled cross pollinations was begun in an attempt to elucidate the genetic relationships between the species of Petalostemon. Parent plants representing 11 of the 31 species were grown either from seed or field-collected rootstocks and maintained under greenhouse conditions during the course of the experiment. Cross pollinations were made, the seeds harvested, counted, planted and progeny grown. In a few cases, second generation hybrids were produced. In addition to the insights into the genetic relationships of the species, this part of the research provided an almost constant supply of cytological material, flowers and pollen for further investigations.

Petalostemon proved to be an ideal subject for this type of biosystematic research because the plants rarely set seeds if kept in an insect free environment. The mechanisms preventing self-pollination are not primarily genetic; rather, they are morphological. Almost all species are protandrous, the anthers are exerted and the pollen exposed prior to stigmatic receptiveness. Additionally, the filaments diverge from the longitudinal axis of the flower so that the anthers are spatially quite remote from the stigma when it does become receptive. Another factor involved is that the style is long and the stigma extends well beyond the anthers. One species that lacks both divergent filaments as well as an elongate

style is P. obovatum. This species is entirely self pollinating in the greenhouse, setting seeds readily without outside intervention.

The degree of interfertility between species was measured by the percentage of seeds set in a given cross. Usually all the pods of a particular spike were examined. This number ranged from a minimum of 20 to a maximum of 261. The average number of pods examined for each cross was 32. The results of all attempted cross pollinations are shown in Table 1. A seed set of less than 10% is interpreted as indicating complete intersterility. This small percentage appears to represent infrequent self pollinations, often resulting from stylar bending that allows a stigma of one flower to touch the anther of a contiguous one. In Table 1, the species are arranged according to sectional groupings based on morphological similarities. It will be seen that within a given section, fertility between the species is high, while between sections it is quite low, if existent at all. As a result of progeny analysis, only one intersectional hybrid was verified, that from a cross between P. candidum and P. tenuifolium, with the former the pistillate parent. P. candidum is white flowered while P. tenuifolium is purple. The hybrid was intermediate in color as well as all other characteristics. A possible second intersectional cross indicated in Fig. 20 by the question mark is based on rather indirect evidence. The cross was between P. villosum and P. occidentale, the former the

Table 1. Results of attempted cross-pollinations in the genus Petalostemon. All numbers are expressed in percentage of seed set. The asterisk (*) signifies a self-pollination or progeny phenotypically like the female parent

Male parents	Female parents												
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)		
<u>P. purpureum</u> (A)	15 48 34	24 24 61	45 30	0	8 0	2 30 12	0 10	10* 5* 3.5*	0 0	0	-- 0 2.4*	--	
<u>P. tenuifolium</u> (B)	16 9.6 7.8	0 34 45	55	--	2.4	4 4 17	12 22	12*	0 67* 26*	13*	-- 0	0	
<u>P. tenue</u> (C)	31 2.5 19	53 0 0	37	--	19 9	21 16 20	6 10	-- 0	--	0	3.8*	--	
<u>P. pulcherrimum</u> (D)	21 45	4 50	10	0	1	3 17	--	0 21*	0	--	2.6*	0 0	
<u>P. arenicola</u> (E)	41 36 58	45 57 25	19 14	0 0	0 8 11 13	7 53 27	0	34* 0 43	0	0 0	0 0	0	
<u>P. gattingeri</u> (F)	53	23	--	0	37	45	--	--	--	--	0	--	
<u>P. candidum</u> (G)	0 2.3*	0 0	--	--	0	--	--	--	10 11	61	31 0	2* 0	
<u>P. occidentale</u> (H)	--	9.1* 0 6.7*	--	--	5.6* 0 0	--	10 50 35	--	27	--	28 29	12* 0 1.3*	
<u>P. multiflorum</u> (I)	--	--	--	--	--	--	--	--	--	--	--	--	
<u>P. villosum</u> (J)	4.3* 0	0 0	--	0 0	12.5* 0 0	--	0	--	34* 20*	--	0 0	46 0 0	12* 0 0
<u>P. microphyllum</u> (K)	0 0 0	1.8 0	0	0 0	0	--	2.8* 30* 0	--	0 0 0	7.5* 0 0	0 0	0 0	4.7

pistillate parent. The progeny, phenotypically, was like P. villosum but most of the flowers were abnormal. Many lacked corolla segments and/or stamens, others showed various kinds of androecial fusions. These abnormalities could have been the result of self pollination resulting in increased homozygosity of deleterious recessive genes, however; no other P. villosum crosses showed such abnormalities, including several self crosses.

Within sections, all crosses showed phenotypic intermediacy between both parents with but few exceptions. One of the exceptions was the unique retrorse calyx pubescence characteristic of P. tenue (P. stanfieldii). Of the progeny examined when this species was the staminate parent, none had retrorse calyx pubescence even though intermediacy was seen in all other characteristics. It is possible that this character is controlled by a single recessive gene.

One of the anticipated results of these crosses was the synthesis of one or several of the preexisting species of Petalostemon. A cross between P. gattingeri and P. purpureum resulted in such a synthesis. The progeny of this cross was phenotypically identical with P. arenicola. Although the present range of the two parents is allopatric, it is possible that sympatry existed in the past and that hybrid populations proved adapted to a particular "ecological niche" and persisted. However, phenotypic resemblance is equivocal and need not imply the derivation of an entire species from two extant

species. A specimen is in ISC.

Another result of this study was the discovery that male sterility within populations is a relatively common phenomenon in Petalostemon. This is not an artifact of greenhouse culture. It first came to my notice in the greenhouse when certain plants of P. purpureum, P. candidum and P. multiflorum consistently produced flowers with shrunken anthers containing no pollen yet appeared fully female fertile and set seeds when pollinated with pollen from other plants. Later, close observation in the field showed that indeed, the field populations contained both male sterile and male fertile plants. On a prairie remnant adjacent to the Ames High School, Story Co., Iowa, both P. purpureum and P. candidum grow sympatrically. Ten of 12 P. purpureum and 27 of 35 P. candidum plants collected here were male sterile.

The obvious advantage of male sterile plants in pollination experiments is that the possibility of accidental self-pollination is eliminated. All three male sterile species in cultivation have thus yielded unequivocal data in this study. One aspect of this male sterility phenomenon is that the progeny of these plants resulting from hybridization with another species in the same section are always male sterile even though they are intermediate in all other phenotypic aspects. This characteristic is possibly the result of one

or a group of dominant genes.

Some evidence has accumulated from the studies involving these male sterile plants indicating that "foreign" pollen can induce parthenogenetic seed formation. Crosses involving male sterile P. candidum plants and some of the purple species, e.g. P. purpureum, P. tenuifolium, P. pulcherrimum and P. arenicola, produced relatively high seed set yet the progeny were phenotypically like the pistillate parent. It is probable that embryo development is parthenogenetic and the foreign pollen merely acts as a trigger for this type of reproduction. Although all the specimens of P. occidentale used were fully male fertile, perhaps parthenogenetic seed formation was responsible for the high seed set with pollen from P. tenuifolium and P. villosum (Table 1). In this case, too, all the progeny were phenotypically P. occidentale.

In summary, there are genetic barriers between the sections of the genus. Thus two species belonging to different sections can exist sympatrically with little, if any genetic interchange. Within sections, however, interfertility is common, but geographical or ecological separation of species is almost always found. If two species belonging to the same section come in contact, hybrids result. Such a situation undoubtedly occurs in southeastern Oklahoma resulting in hybridizations between P. purpureum, P. pulcherrimum and P. decumbens. From my greenhouse study, the hybrids seem fully fertile and vigorous but this in no way measures their ability

to compete in their natural environments. Their success is probably variable, but if given the appropriate favorable environment, they will persist.

Compatibility within the four sections tested (Purpurei, Phleoides, Candidi and Villosi) is summarized in Fig. 20. Compatibility within selected members of section Purpurei is summarized in Fig. 21.

Fig. 20. Diagram showing attempted crosses between members of the sections of Petalostemon. The arrows indicate the direction of pollen transfer. Attempted crosses where less than 5% seed set resulted are indicated by a broken line. The solid lines indicate verified hybrids were produced

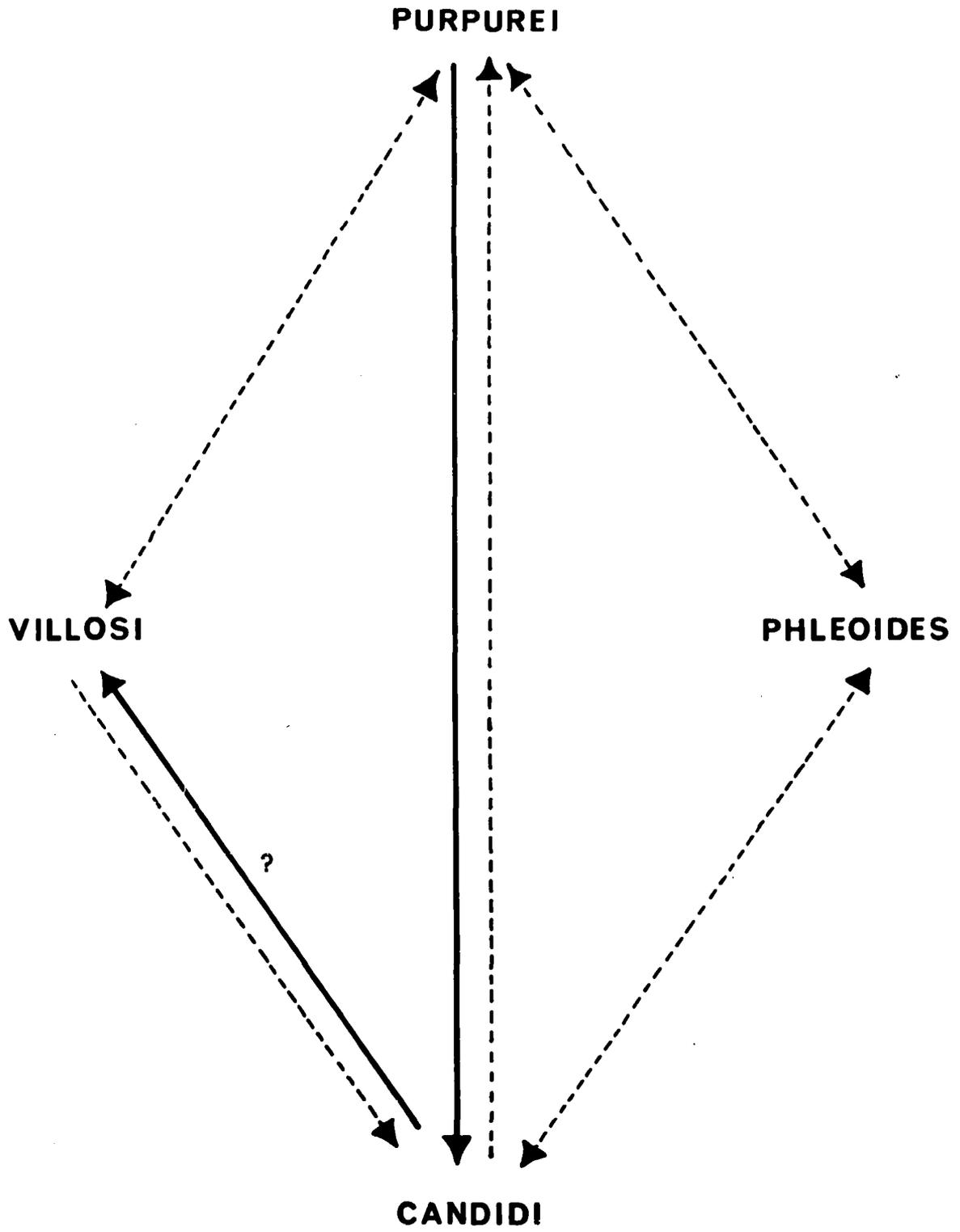
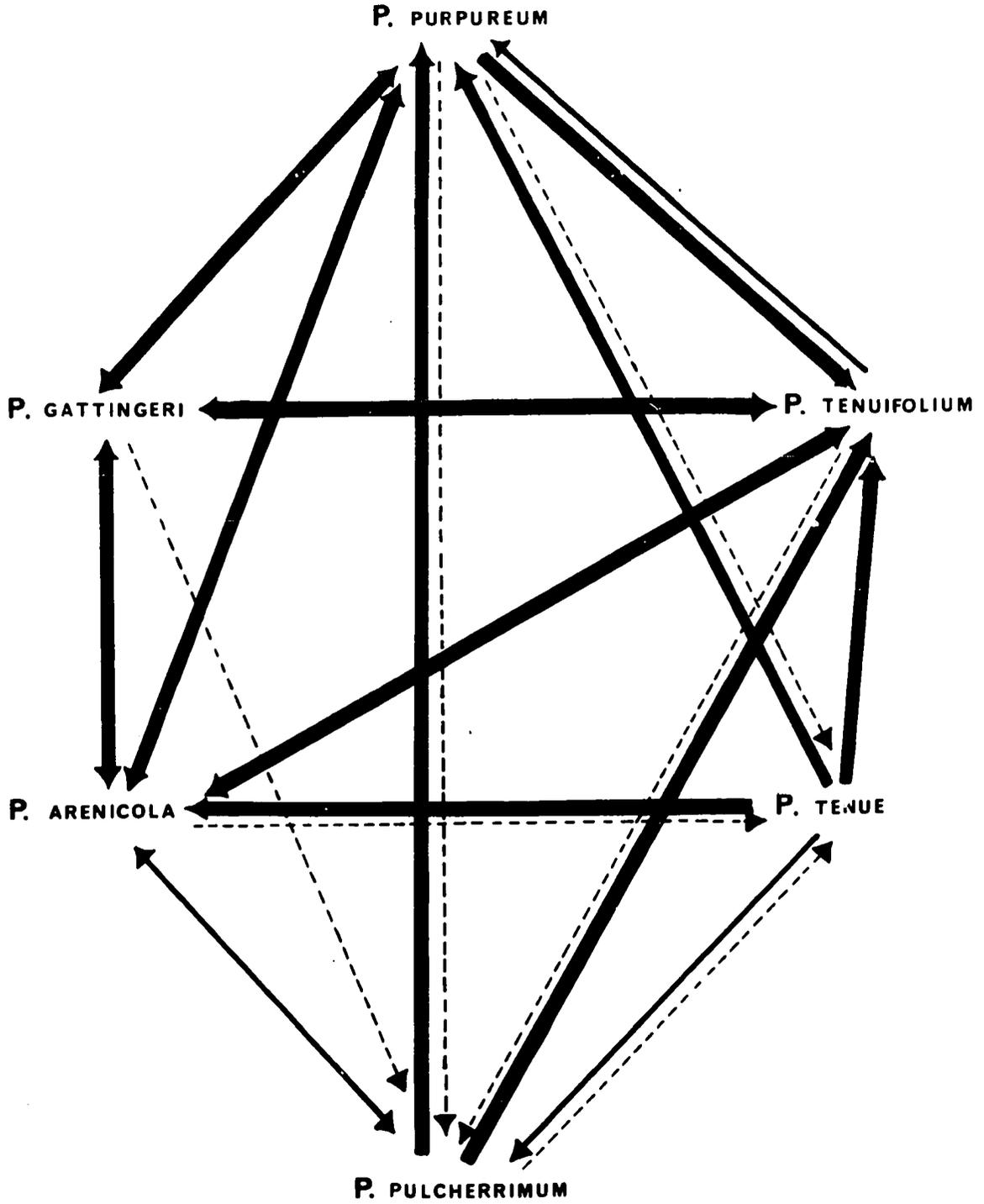


Fig. 21. Diagram showing attempted crosses between members of section Purpurei in Petalostemon. The arrows indicate the direction of pollen transfer. Attempted crosses wherein less than 5% seed set resulted are indicated with a broken line. The thin, solid line represents 5-10% seed set. The wide, solid line represents a seed set greater than 10%



CYTOLOGICAL STUDIES

Cytological studies using root tips and microsporocyte preparations were made on eleven species, eight interspecific hybrids and one F₂ interspecific hybrid. Eight of the species counts have not previously been reported. A summary of my counts and those of other workers is presented in Table 2 and selected illustrations of the meiotic and mitotic figures are shown in Figs. 22, 23. Voucher specimens for each of the counts were deposited in ISC except when otherwise noted.

All counts previously made as well as my own show Petalostemon to possess a diploid number of 14. There were no consistent meiotic abnormalities either in the species or the hybrids that I examined. Occasional examples of binucleate pollen mother cells, such as those reported by Sen and Krishnan in Clitoria ternata (1961), were observed.

An attempt was made to study meiosis in specimens of Petalostemon that were male sterile, but I was unable to observe any meiotic figures in anther preparations from these plants. It is possible that the disturbance resulting in male sterility takes place prior to meiosis, perhaps in pollen mother cell formation.

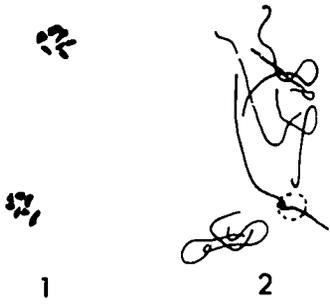
Table 2. Chromosome numbers reported in the genus Petalostemon. All counts are $2n = 14$. The asterisk (*) indicates previously unreported counts

Species	Reference and/or collection data
* <u>P. albidum</u>	Wemple: Alachua Co., Florida, <u>Isely & Wemple 9257</u> . Columbia Co., Florida, <u>Isely & Wemple 9372</u> .
* <u>P. arenicola</u>	Wemple: Kearney Co., Kansas, <u>Wemple 319</u> .
<u>P. candidum</u>	Ledingham (1957). Turner (1959).
* <u>P. carneum</u>	Wemple: Citrus Co., Florida, <u>Isely & Wemple 9271</u> .
* <u>P. carolinense</u> ssp. <u>carolinense</u>	Wemple: Alachua Co., Florida, <u>Isely & Wemple 9246</u> .
* <u>P. carolinense</u> ssp. <u>trifoliatum</u>	Wemple: Holmes Co., Florida, <u>Isely & Wemple 9177</u> . Leon Co., Florida, seeds collected by A.M. Clewell from same location as <u>Clewell 758</u> . No voucher specimen retained.
<u>P. feayi</u>	Turner (1963). Wemple: Highlands Co., Florida, <u>Isely & Wemple 9316</u> .
* <u>P. gattingeri</u>	Wemple: Franklin Co., Alabama, <u>Wemple 470</u> .
<u>P. glandulosum</u> (synonymous with <u>P. phleoides</u> in this treatment)	Turner (1956).
* <u>P. gracile</u>	Wemple: Jackson Co., Mississippi, <u>Isely & Wemple 9110</u> . Mobile Co., Alabama, <u>Isely & Wemple 9115</u> . Baldwin Co., Alabama, <u>Isely & Wemple 9129</u> .
<u>P. griseum</u>	Turner (1959). Turner & Fearing (1960).

Table 2 (Continued).

Species	Reference and/or collection data
* <u>P. microphyllum</u>	Wemple: from seeds collected in Callahan Co., Texas by N.C. Henderson, <u>Wemple greenhouse No. 65B</u> .
<u>P. pulcherrimum</u>	Turner (1956). Wemple: from seeds collected in Travis Co., Texas, <u>Wemple greenhouse Nos. 8J, 8M</u> . Grimes Co., Texas, <u>Wemple & Jackson 717</u> .
<u>P. purpureum</u>	Ledingham (1957). Wemple: from seeds collected in Sumter Co., Alabama, <u>Shinners 12634</u> . From seeds collected in Clark Co., Arkansas, <u>Demaree 38695</u> .
<u>P. stanfieldii</u> (synonymous with <u>P. tenue</u> in this treatment)	Turner (1956).
* <u>P. tenuifolium</u>	Wemple: from seeds collected in Ochiltree Co., Texas, <u>Wallis 4806</u> .
<u>P. villosum</u>	Ledingham (1957).

Fig. 22. Meiotic and mitotic figures in species of Petalostemon. A. P. albidum; 1. anaphase II, 2. pachytene. B. P. arenicola. C. P. carneum. D. P. caroliniense ssp. carolinense. E. P. caroliniense ssp. trifoliatum; 1. mitosis (two cells), 2. pachytene. F. P. feayi. G. P. gattingeri. H. P. gracile; 1. diakinesis, 2. metaphase. I. P. microphyllum, anaphase II. J. P. pulcherrimum; 1. diakinesis, 2. pachytene. K. P. purpureum. L. P. tenuifolium



A



B



C



D



E



F



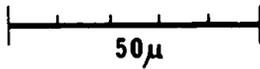
G



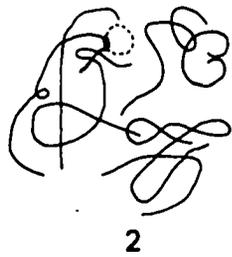
H



I



J

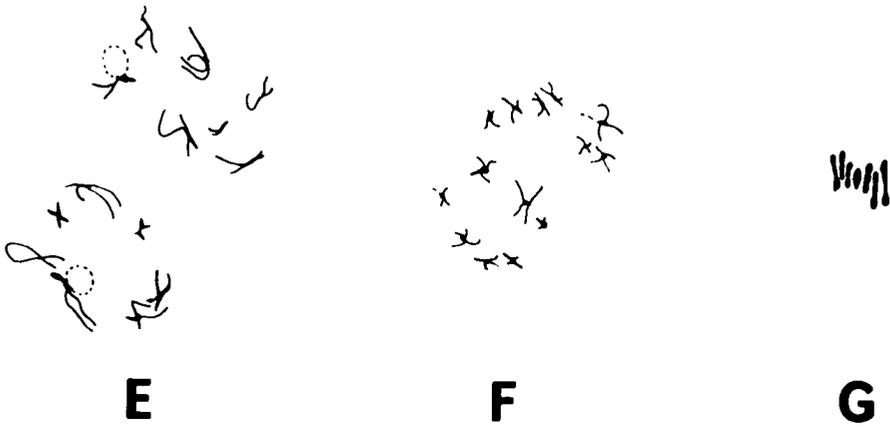
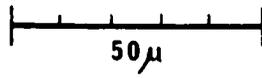


K



L

Fig. 23. Meiotic figures in interspecific hybrids of Petalostemon. A. P. tenuifolium x P. arenicola; 1. pachytene, 2. anaphase II. B. P. arenicola x P. tenuifolium. C. P. arenicola x P. pulcherrimum, two cells. D. P. arenicola x P. purpureum. E. P. gattingeri x P. tenuifolium, two cells. F. P. pulcherrimum x P. purpureum, two cells. G. (P. tenuifolium x P. arenicola) x self



POLLEN ANALYSIS

Pollen investigations, particularly those involving size and shape relationships, have heretofore been undertaken mainly by paleobotanists. The topic can hardly be introduced without mention of the works of G. Erdtman (1952, 1954), but the primary focus of these books, even though they are taxonomic in implication, is the study of fossil pollen. Two recent papers have pointed out the importance of pollen analysis as an additional tool for the systematist dealing with modern plants (Horton 1963; Stone 1963).

Horton and Stone utilized freshly collected pollen for their studies. I used fresh pollen also, but found it is equally feasible, in the case of Petalostemon, to use pollen from herbarium sheets. Drying apparently has little effect on the exine and if the investigator is interested primarily in external dimensions of the grains, 24 hours in lactophenol and cotton blue, is sufficient to inflate the grains to their normal size.

The pollen of Petalostemon varies in shape from subprolate to prolate (Erdtman 1954). The larger pollen grains of the section Purpurei tend to be more elongate than those of the other sections which possess smaller, more spheroidal grains. The tricolpate grains appear only slightly sculptured under 430x magnification. They bear no irregularities or protuberances.

To the naked eye the pollen is yellow or orange; the color is due to an orange liquid which adheres to the grains. This substance is immiscible in lactophenol but has not been further characterized. It is especially prevalent in members of section *Purpurei* -- the species that possess yellow-orange or orange pollen. Representatives of the other sections have yellow pollen.

Pollen viability, as tested with cotton blue, is high in almost all species. In all except *P. tenuifolium* and *P. villosum* the number of aborted or non-staining pollen grains was always less than 1%. *P. tenuifolium* was unique in that the grains showed wide variations in size and shape. This is indicated by the relatively wide range of both length and width measurements as well as a large standard deviation for both (Table 3, Fig. 24). In addition to size and shape variation, there was invariably 5--15% non-staining pollen in each sample. *P. villosum*, while having uniform pollen size, usually showed about 10% non-staining pollen.

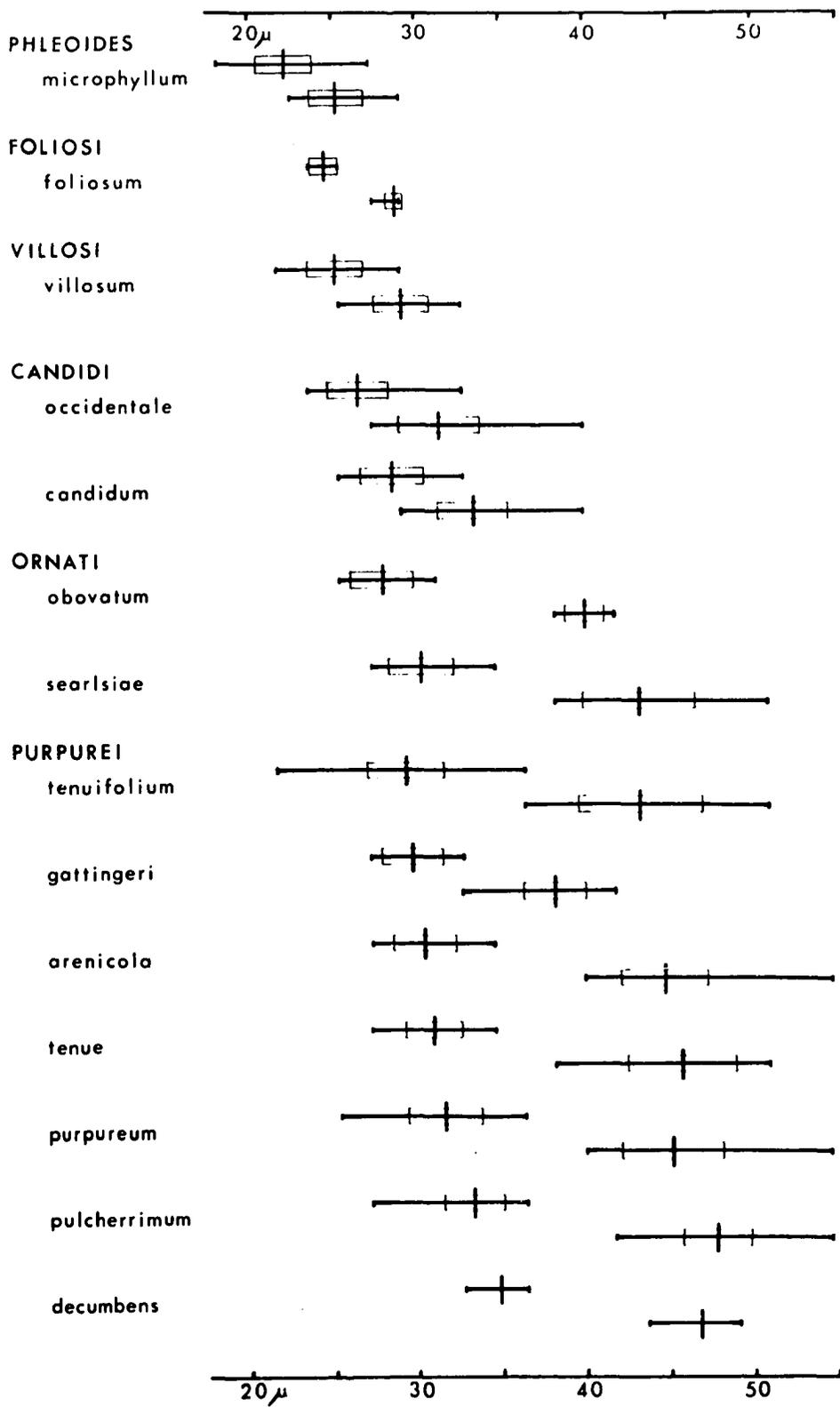
Measurements and their analysis are presented in Table 3 and Fig. 24. The species are grouped according to sections and within the sections, on variations in pollen size and shape. It is evident that the measured pollen characteristics coincide with the external morphological characteristics upon which the sections are based.

Several tentative generalizations can be drawn from this data: 1.) Members of section *Purpurei* seem related in the

Table 3. Pollen analysis of species of Petalostemon. Asterisk (*) indicates that all measurements were from dried pollen taken from herbarium specimens

"Section"	Species	No. of samples	No. of plants	Width in μ			Length in μ		
				Range	Arithmetic mean	Standard deviation	Range	Arithmetic mean	Standard deviation
Phleoides	<u>microphyllum</u>	10	7	18-27	22.23	1.61	24-29	26.34	1.62
Foliosi	<u>foliosum</u>	2	2	23-25	24.55	0.93	27-29	28.91	0.55
Villosi	<u>villosum</u>	10	10	22-29	25.23	1.57	25-33	29.09	1.70
Candidi	<u>occidentale</u>	11	8	24-33	26.41	1.79	27-40	31.32	2.47
Candidi	<u>candidum</u>	8	5	25-33	28.61	1.91	29-40	33.39	2.07
Ornati	<u>obovatum</u>	2	2	25-31	28.0	1.81	38-42	39.99	1.18
Ornati	<u>searlsiae*</u>	4	4	27-35	30.27	1.91	38-51	43.18	3.31
Purpurei	<u>tenuifolium</u>	7	5	22-36	29.32	2.26	36-51	43.17	3.68
Purpurei	<u>gattingeri</u>	5	4	27-33	29.78	1.78	33-42	38.15	1.78
Purpurei	<u>arenicola</u>	7	5	27-35	30.49	1.89	40-55	44.75	2.58
Purpurei	<u>tenue</u>	4	3	27-35	30.95	1.67	38-51	45.77	3.24
Purpurei	<u>purpureum</u>	13	10	25-36	31.01	2.19	40-55	45.01	3.01
Purpurei	<u>pulcherrimum</u>	15	14	27-36	33.24	1.75	42-55	47.84	2.09
Purpurei	<u>decumbens</u>	1	1	33-36	34.91	Not calculated	44-49	46.73	Not calculated

Fig. 24. Pollen size and shape analysis of selected species of Petalostemon. Length of the horizontal line indicates the range of variation in width (upper line) and length (lower line). The central cross mark indicates the arithmetic mean for all grains sampled. The rectangle represents + or - one standard deviation



possession of large, prolate pollen grains. 2.) The pollen size of P. searlsiae is interesting because this species has many characteristics which suggest that it is allied with the Purpurei -- most specifically with P. tenuifolium whose pollen size P. searlsiae closely approximates. The morphological basis for including the latter species in the Ornati rather than the Purpurei will be discussed later. 3.) Sections Phleoides, Foliosi and Villosi possess small subprolate pollen grains. Morphologically these sections are quite distinct from one another, yet they are unique among the Petalostemon in that they all possess a high leaflet number (15 or more).

I have also examined the pollen of most of the artificial hybrids that I have synthesized as well as that of a naturally occurring hybrid between P. purpureum and P. pulcherrimum (Table 4 (Wemple 402, Marshall Co., Okla.)). Usually pollen size of the hybrid is intermediate in size between that of either parent -- this intermediacy parallels that shown by the hybrids in other morphological characteristics. Seldom is the viability of the pollen substantially reduced except in the case of all P. tenuifolium hybrids, where the "abnormalities"-- size and shape variation and inviability -- of the P. tenuifolium parent appear to be emphasized. This variation was noted in crosses with all other species and seemed to hold true regardless of whether P. tenuifolium was used as the staminate or pistillate parent. Data is also presented on a

limited number of second generation hybrids, most of which show a high proportion of abnormal pollen grains.

Table 4. Pollen analysis of interspecific hybrids of Petalostemon. SSV indicates that size and shape variation was noted. Abnormalities are indicated in % of the sample that appeared abnormal. Asterisk (*) indicates a field collected hybrid between P. purpureum and P. pulcherrimum (Wemple 402 Marshall Co., Okla.)

Female parent	Male parent	No. of samples	No. of plants	Width in μ		Length in μ		Abnormalities
				Range	Mean	Range	Mean	
<u>P. candidum</u>	X <u>P. occidentale</u>	2	2	25-31	28.0	33-36	33.91	8%
<u>P. tenuifolium</u>	X <u>P. purpureum</u>	4	3	29-33	31.05	36-47	42.77	SSV, 15-70%
<u>P. purpureum</u>	X <u>P. tenuifolium</u>	1	1	31-36	32.0	40-51	44.91	5%
<u>P. tenuifolium</u>	X <u>P. pulcherrimum</u>	1	1	29-33	31.09	44-47	45.64	--
<u>P. tenuifolium</u>	X <u>P. arenicola</u>	14	13	25-35	29.88	33-47	42.91	SSV
<u>P. arenicola</u>	X <u>P. tenuifolium</u>	1	1	25-33	30.18	40-46	40.36	SSV
<u>P. gattingeri</u>	X <u>P. tenuifolium</u>	1	1	29-33	30.36	36-42	39.09	SSV, 20%
<u>P. gattingeri</u>	X <u>P. purpureum</u>	2	1	25-31	28.82	36-44	36.29	SSV
<u>P. purpureum</u>	X <u>P. gattingeri</u>	2	2	27-33	30.09	42-51	44.10	SSV
<u>P. arenicola</u>	X <u>P. gattingeri</u>	1	1	29-31	29.45	38-44	42.54	--
<u>P. arenicola</u>	X <u>P. purpureum</u>	2	2	29-35	30.91	42-51	46.36	--
<u>P. arenicola</u>	X <u>P. pulcherrimum</u>	3	3	29-36	32.16	42-51	45.27	--

Table 4 (Continued).

Female parent	Male parent	No. of samples	No. of plants	Width in μ		Length in μ		Abnormalities
				Range	Mean	Range	Mean	
<u>P. pulcherrimum</u>	X <u>P. arenicola</u>	3	3	29-36	32.24	40-53	45.51	--
<u>P. purpureum</u>	X <u>P. pulcherrimum</u>	1	1	33-35	33.27	42-51	44.73	--
<u>P. pulcherrimum</u>	X <u>P. purpureum</u>	2	1	31-36	33.18	36-45	47.84	--
<u>P. purpureum</u>	X <u>P. tenue</u>	3	2	29-33	30.61	42-45	42.97	--
402*		3	1	31-36	32.91	47-56	51.15	--
<u>P. tenuifolium</u>	X 402*	1	1	29-33	31.09	40-47	44.0	SSV
<u>P. purpureum</u>	X 402*	2	2	29-36	32.73	42-47	44.36	30-60%
402*	X <u>P. arenicola</u>	1	1	29-33	30.91	47-53	48.91	--
(<u>P. tenuifolium</u> X <u>P. arenicola</u>) X Self		3	3	27-33	30.18	40-45	42.54	SSV, 10%
(<u>P. arenicola</u> X <u>P. gattingeri</u>) X Self		2	2	27-35	29.91	38-45	39.91	SSV, 5%
(<u>P. purpureum</u> X <u>P. gattingeri</u>) X Self		1	1	33-38	34.73	40-45	43.27	40%

THE GENUS PETALOSTEMON

Petalostemon Michx. Fl. Bor. Am. 2: 48. (1803). Nom. Cons.
Type species P. candidum Michx. Type material in P.

Kuhnistera Lam. Encycl. Meth. 3: 370. (1789).

Dalea Juss. Gen. Pl. 355. (1789). quoad descr.

Psoralea Poir., in Lam. Encycl. 5: 694. (1804). pro parte.

Generic description

Perennial, glandular-punctate herbs with many stems arising from a well developed taproot or caudex (Fig. 54F). Stipules subulate. Leaves usually with smaller leaves or reduced stem systems in their axils, odd-pinnate, with (3) 5--numerous leaflets; leaflets usually narrow to elliptical but sometimes broad and almost ovate, usually \pm involute. Flowers in terminal, globose to cylindrical spikes, each flower subtended by a conspicuous bract which usually exceeds the length of the calyx in bud; the flowers of some species also with bracteoles flanking the base of the calyces. Calyx campanulate to tubular, 3.0--7.5 mm long (including lobes), sometimes oblique; the lobes deltoid to lanceolate or, less frequently, filiform plumose. Standard long-clawed, arising from a socket near the floral base, the blade oblong to cordate; the four other petals arising from the apex of the staminal tube, or slightly below, interdigitating with the 5 monadelphous stamens; claws inserted in prominent sockets;

blades strap-shaped to oblong, spreading from the floral axis. Free portions of the filaments usually diverging from the floral axis, equalling or exceeding the length of the androecial tube and usually subequal to the petal apices at anthesis. Ovary globose to elliptical, 2-ovulate; the style equalling or exceeding the petal apices and anthers shortly after anthesis. Pod ovate to lunate, 1 seeded; the styler beak offset to the standard side of the calyx at maturity. The indehiscent legume falling enclosed in the calyx.

Distribution

Ranging from northern Mexico throughout much of the United States north to southern Canada. The greatest number of species is found in Texas. One complex extends from the Great Basin northward into the Pacific Northwest. Another is found in the southeastern states. The principal area in which Petalostemon is absent is the northeastern deciduous forest.

Key to the subgenera

1. Spikes subglobose, compact, disposed in a corymbose manner, surrounded by a series of oval to reniform, sterile bracts; calyx lobes filiform and plumose; flowers white; restricted to the southeastern states.

I. Kuhnistera page 63

1. Spikes various, rarely subglobose or corymbosely disposed, seldom with sterile bracts at the base of the spikes; calyx lobes deltoid or lanceolate; flowers variously colored; not restricted to the southeastern states.

II. Petalostemon page 78

I. Subgenus KUHNISTERA (Lam.) Wemple comb. nov.

Kuhnistera Lam. Encycl. Meth. 3: 370. (1789).

Introduction

The three taxa composing subgenus Kuhnistera are united by the possession of three distinctive characteristics: 1.) subglobose, compact spikes surrounded by a series of oval to reniform, sterile bracts; 2.) spikes disposed in a corymbose manner; and 3.) filiform and plumose calyx lobes. None of these characteristics are unique within Petalostemon but their combination in this geographically restricted trio of species, clearly sets this subgenus apart. The plants are endemic to the southeastern Coastal Plain of southern Mississippi, Alabama, Florida, Georgia, South Carolina and North Carolina. Within this area they are found only on the more elevated, drier, sandy areas, locally called "sandhills." They are usually associated with pines and scrub oaks. Ecologically they are sympatric through part of their range with Petalostemon albidum and P. feayi. They are the only species of

Petalostemon with representation in the Carolinas.

Meiotic and mitotic preparations of P. caroliniense yield 7 and 14 chromosomes respectively, consistent with the rest of the genus (Table 2, Fig. 22, D, E). Pollen collected from P. caroliniense ssp. trifoliatum, (Isely & Wemple 9177), Holmes county, Florida, appeared typical of the genus, in length averaging 29 microns, in width 20 microns.

Key to the Species

1. Leaflets over 2 mm wide; stems with spherical, protuberant "glands" becoming more numerous toward the apex of the stem; limited to the Florida peninsula.

1. P. adenopodum p. 64

1. Leaflets less than 2 mm wide, generally filiform; "glands" present on the stem but not spherical-protuberant; not limited to the Florida peninsula.

2. P. caroliniense p. 72

Taxonomy

1. PETALOSTEMON ADENOPODUM (B. L. Robs. ex Rydb.) Wemple (Fig. 25)

Petalostemon adenopodum (B. L. Robs. ex Rydb.) Wemple.
Based on Kuhnistera adenopoda B. L. Robs. ex Rydb.

[Improperly published as Kuhnistera adenopoda (B. L. Robinson) Rydberg. N. Am. Fl. 24: 136. (1919-1920)].

Petalostemon corymbosum adenopodum B. L. Robs. M. S. in herb. Type in GH. (1).

Kuhnistera truncata Small. Bull. Torr. Bot. Club 51:
380-381. (1924). Type material in NY. (2).

Description

Plants lacking a prominent caudex, the root often red. Stems dark, glabrous and striate, 1 m or shorter, covered with spherical, protuberant secretory cavities ("glands") about 1 mm in diameter, increasing in abundance toward the stem apex. Leaves fascicled, less than 2 cm long with 3--7 elliptical leaflets, usually 2--3 mm wide and 6--8 mm long, paler green on top surface, often involute. Inflorescence corymbose with peduncles below the individual flower spikes lacking, the leaves gradually merging into involucre-like, oval to reniform, sharply acuminate, ciliate, sterile bracts. Calyx villous, tube 2--3 mm long, lobes plumose, 4.0--4.5 mm long. Corolla white, standard lanceolate, sometimes truncate, 0.8 mm wide, 3.5 mm long, equalling claw; apical petals lanceolate, sometimes truncate, blades 1.0 mm wide, 3.0 mm long, claw 1.2 mm long. Androecial tube 5--6 mm long, almost equalling tips of calyx lobes, stamen filaments 4.0 mm long, spreading at anthesis. Ovary 2.0 mm long, bearded on the distal 2/3, predominantly so on the upper surface; style 10.0 mm long bearded proximally over 1/2 its length.

Distribution and phenology

Restricted to the lower half of peninsular Florida.¹
 Limited to the higher, drier sandy areas. Often associated with turkey oak (Quercus laevis Walt.), long leaf pine (Pinus australis Michx.) and saw palmetto (Serenoa repens Small), a habitat similar to that occupied by P. caroliniense to the north. Geographically and ecologically sympatric in part of its range with P. feayi.

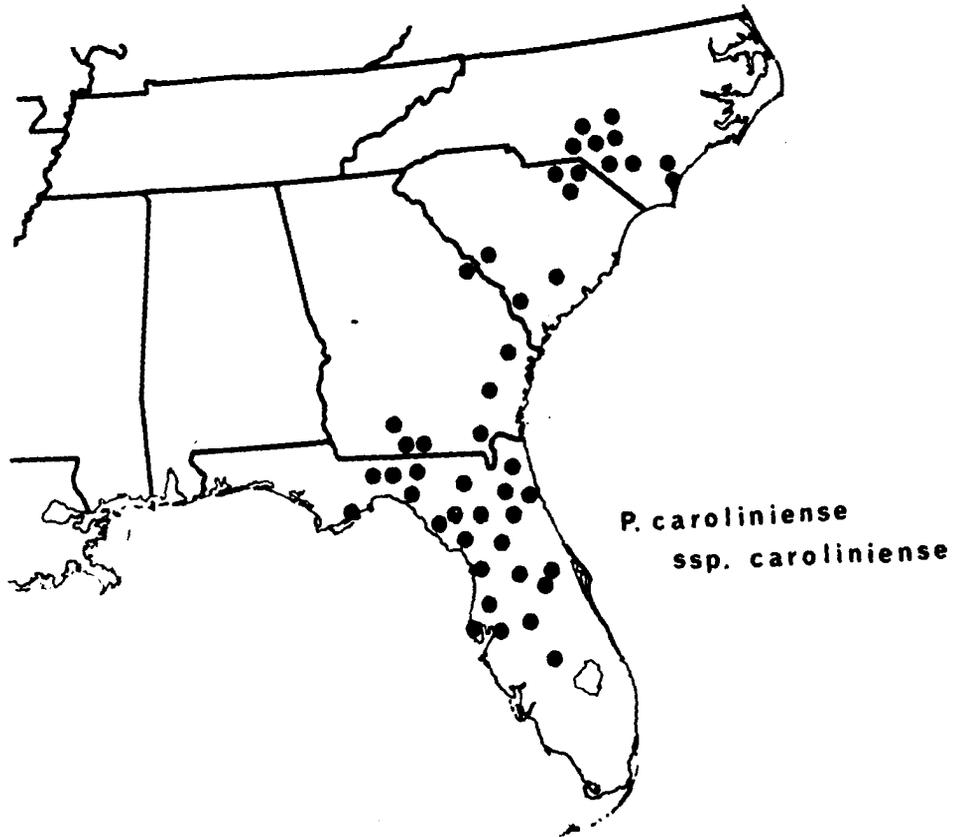
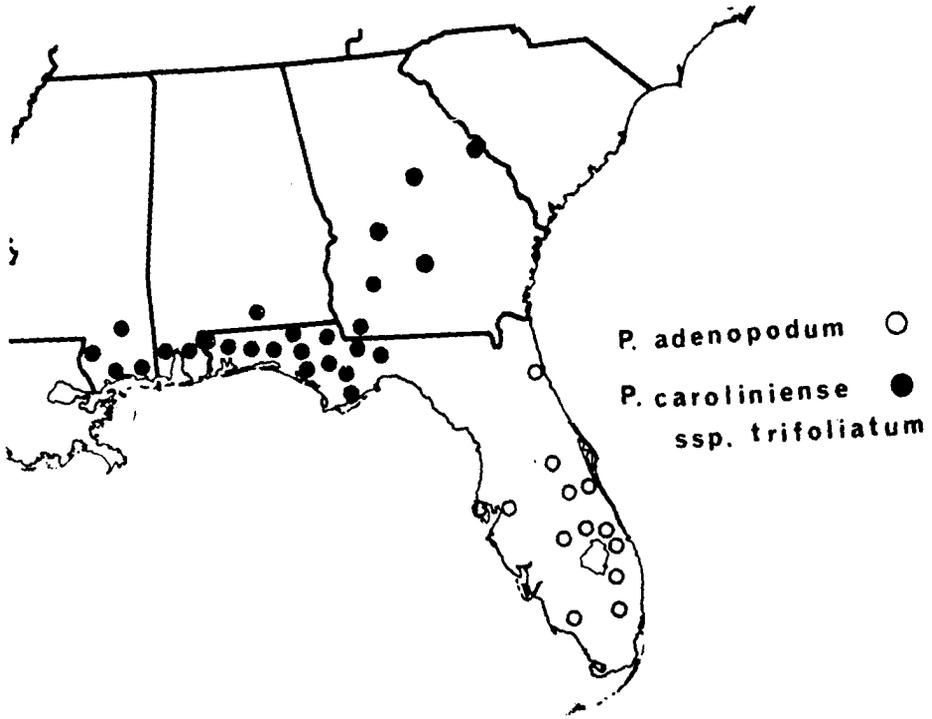
Anthesis from mid September to late November.

Nomenclature and observations

This species was first described by Rydberg (1919-1920) who based his name on a B. L. Robinson annotation label. The type sheet is a mixture of P. adenopodum and P. caroliniense ssp. caroliniense. Robinson identified both on the annotation label as respectively: "P. corymbosum, var. adenopodum, Rob. n. var." and "P. corymbosum, Michx. typical form." Rydberg's description is headed by: "2. Kuhnistera adenopoda (B. L. Robinson) Rydberg sp. nov.," giving Robinson full credit for the specific epithet even though it was not validly published. I have designated the citation as, "Robs. ex Rydb.," a

¹A northern extension to the range is suggested by three collections from St. Johns county in northeastern Florida. All are collections of Mary C. Reynolds (1874-1877). The labels state St. Augustine, Florida. It is possible that this was her place of residence and not necessarily the location where the plants grew.

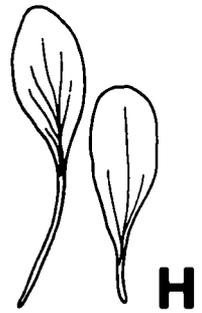
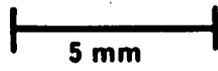
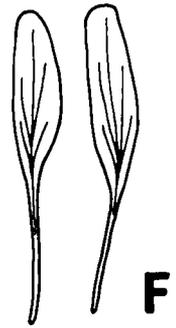
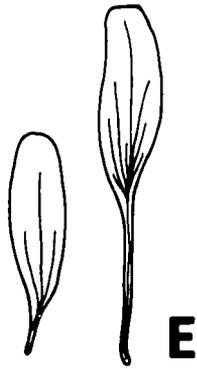
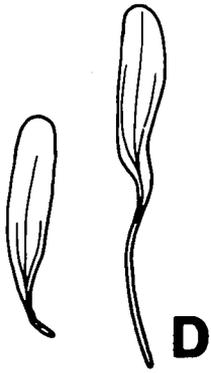
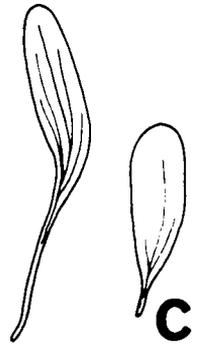
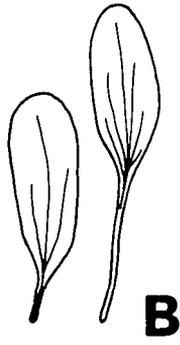
Fig. 25. Geographic distribution of the species of subg.
Kuhnistera



procedure which is possibly not without question but seems the most logical course. Rydberg limits the species to the Tampa Bay Region of Florida's west coast, the location of the original Garber collection on which the name was based.

Small proposed the species Kuhnistera truncata based on an F. C. Rane collection at Earman, Florida, March 2, 1921, also citing other collections along the east coast of Florida at Jupiter, "many years ago," by C. Hitchcock. Small's discussion is confusing since he begins with an acknowledgment of Rydberg's K. adenopoda and then compares his species with K. pinnata (P. caroliniense) rather than K. adenopoda. He comments on the differences in leaflet width and the more open inflorescence in his species, but attaches special emphasis to the truncate petals. He makes no explicit comparison with K. adenopoda. Had he done so, he would have found no essential differences. With regard to petal shape, I have examined petals of specimens throughout the range of P. adenopodum including several sheets annotated in Small's hand, "K. truncata." Fig. 26 shows examples of the variation found. There seems to be no correlation between petal conformation and distribution. In contrast to P. caroliniense, the petal shape is quite different, as Small points out. It is possible that Small, in studying specimens from the east coast of Florida and presuming that Rydberg's species, K. adenopoda, was restricted to the west coast, cast around for a character on which to base a new species and seized on the apparent

Fig. 26. Petal variation in subgenus Kuhnistera. A.--H.,
apical petals and standards of P. adenopodum.
I., apical petals and standard of P. caroliniense
ssp. caroliniense. A. Garber year 1877,
Hillsborough Co., Fla. (isotype of P. adenopodum).
B. Schallert 20850, Orange Co., Fla. C. Reynolds
10025, St. Johns Co., Fla. D. Deam 2817,
Pinnelas Co., Fla. E. Small 2307, St. Lucie Co.,
Fla. F. West & West 4 Nov. 1945, Martin Co., Fla.
G. Harden et al. 14080, Collier Co., Fla. H.
Kent 24 Oct. 1942, Broward Co., Fla. I. P.
caroliniense ssp. caroliniense, Young, South
Carolina



variation in petal shape.

The poor representation of this species in major herbaria perhaps represents as much a paucity of collectors as a rarity of the plants (see Shinnars 1964). During the course of two days collection across peninsular Florida, *P. adenopodum* appeared common in its preferred habitat.

2. PETALOSTEMON CAROLINIENSE (Lam.) Sprague

Description

Stems slightly branching, up to 1.1 m tall; moderately striate, glabrous with "glands" prominent but not protruding above the surface of the stem and not increasing in number toward the stem apex. Leaves fascicled, 1--2 cm long, bearing 3--13 linear-filiform, usually involute leaflets which are less than 0.9 mm broad. Inflorescence corymbose, simple or compound; peduncles below the individual flower spikes lacking, the apical leaves merging into several whorls of oval to sub-orbicular, ciliate-acuminate, sterile bracts. Flowers disposed in compressed spikes. Calyx villous, tube 2 mm long, lobes plumose-filiform, 3--6 mm long. Corolla white, standard lanceolate, cuneate at the base of the blade, 1 mm wide, 4 mm long, equalling the claw; apical petals similar to the standard but with claws only 1.0--1.5 mm long. Androecial tube 5 mm long, the free portions of the filaments 5--6 mm long. Ovary 2 mm long, the style 10 mm, both bearded.

Key to the subspecies

1. Leaflets 5--13; spikes arranged in a compound corymb; ranging through northern peninsular Florida, western Georgia, South Carolina and North Carolina.

2a. P. caroliniense ssp. caroliniense p. 73

1. Leaflets 3; spikes arranged in a simple corymb; limited to southern Alabama, southern Mississippi, the panhandle of Florida and central Georgia.

2b. P. caroliniense ssp. trifoliatum p. 76

- 2a. PETALOSTEMON CAROLINIENSE SSP. CAROLINIENSE (Lam.)
Sprague (Fig. 25)

Petalostemum caroliniense (Lam.) Sprague. Kew Bull. 1939: 331. (1939). Based on Kuhnistera caroliniensis Lam.

Anonymos Kuhnia affinis pinnat. Walt. Flor. Carol. 102-103. (1788). Type at BM. (1)(2).

Kuhnistera caroliniensis Lam. Encycl. Meth. 3: 370-371. (1789). Based on the description of Anonymos pinnat. Walt.

Dalea kuhnistera Willd. Sp. Pl. 3: 1337. (1802). Based on Kuhnistera caroliniensis Lam.

Petalostemum corymbosum Michx. Flor. Bor. Am. 2: 50. (1803). Based on Anonymos pinnat. Walt.

Psoralea corymbosa Poir. in Lam. Encycl. 5: 694-695. (1804). Based on Petalostemum corymbosum Michx.

Kuhnistera pinnata (Walt.) Kuntze. Rev. Gen. 1: 192. (1891). Based on Anonymos pinnat. Walt.

Petalostemum pinnatum (Walt.) Blake. Rhodora 17: 131. (1915). Based on Anonymos pinnat. Walt.

Distribution and phenology

A common plant of the high, dry, white sand pine scrub. Ranging from central peninsular Florida, where it replaces the more southern P. adenopodum, through eastern Georgia and the Carolinas. Consistently associated with long leaf pine (P. australis) and turkey oak (Q. laevis) and, throughout its Florida range, with Petalostemon albidum.

Anthesis September to early November.

Nomenclature and observations

To my knowledge, the name P. caroliniense has never been used in this country; rather, the taxon has been referred to either P. pinnatum (Walt.) Blake or P. corymbosum Michx. The former lacks priority because the name was first published as Anonymos pinnat., the Anonymos names are outlawed by Article 20 of the Code of Botanical Nomenclature (Lanjouw 1961) and the Blake combination was not made until 1915. The Lamarck epithet is therefore the first published and the combination by Sprague should be adopted.

Typification of Kuhnistera caroliniensis Lam. and Petalostemum corymbosum Michx. deserves comment. Lamarck precedes his description of the species with this paragraph:

En attendant que par un nouvel examen on ait confirmé & déterminé avec une précision convenable les vrais caractères de cette plante, nous en faisons ici une mention succincte d'après ce que nous apprend M.

Walter.,

which I translate as, "Until we have confirmed and determined with suitable precision by a new examination the true characters of this plant, we make of it here a brief mention according to what Mr. Walter tells us about it." Following this paragraph is an almost exact translation of Walter's description. It seems that Lamarck, even though using a new name, is basing it on Walter's description and therefore Walter's type specimen in the British Museum is the type for Kuhnistera caroliniensis.¹ In the same manner, Michaux based P. corymbosum on the Walter name and therefore on the Walter type.

Subspecies caroliniense is distinguished from subspecies trifoliatum by possessing more than three leaflets and having the spikes disposed in a compound rather than a simple "corymb." The range of the two is for the most part distinct, but they are sympatric in Franklin and Leon counties in the panhandle of Florida and in Richmond county in northeastern Georgia. Subspecies caroliniense throughout its southern range usually has five to nine leaflets but specimens with a

¹The wording used by Lamarck suggests that this name could possibly be rejected as a "provisional name" (Article 34, Lanjouw 1961). I consulted several other botanists on this point but they were not of one accord. Two men prominent in nomenclatural matters, Dr. J. E. Dandy of Kew and Dr. H. W. Rickett of the New York Botanical Garden, were both of the opinion that the name is valid and cite several examples of similarly worded notes in Linnaeus' work. I concur with their viewpoint, but as Dr. Rickett stated, "The decision is a close one." (pers. comm. 1965).

higher leaflet number, 11--15, occur in the more northern part of the range, particularly South Carolina. Usually the leaflets are highly involute, presenting an almost filiform appearance. Three collections from South Carolina lack involute leaflets and the plants look remarkably different until one realizes that the leaflets are simply flat rather than tightly rolled. It is possible that these represent a geographic variant of this taxon. The northern populations also frequently show a less well developed inflorescence, some even possessing a simple "corymb" as found in subspecies trifoliatum.

2b. PETALOSTEMON CAROLINIENSE SSP. TRIFOLIATUM (Chapm.) Wemple (Figs. 25, 52C)

Petalostemon caroliniense ssp. trifoliatum (Chapm.) Wemple. Based on Petalostemon corymbosus var. trifoliatum Chapm.

Petalostemon corymbosus var. trifoliatum Chapm. Fl. S. U. S. 100-101. (1897). Type in US. (1)(2).

Gatesia alabamensis Bertol. Novi Comm. Acad. Sci. Inst. Bonon. 9: 212-214, Tab. x fig. 1. (1849). Type destroyed at BOLO during World War II. (2).

Gavesia alabamensis (Bertol.) Walp. Ann. Bot. Syst. 950. (1852). Based on Gatesia alabamensis Bertol. (2).

Distribution and phenology

Limited to southern Mississippi, southern Alabama, the panhandle of Florida and extending northward through the interior of Georgia. Apparently occupying a similar habitat

to that of subspecies caroliniense but largely west of the latter. Associated with long leaf pine (P. australis) and turkey oak (Q. laevis) and ecologically sympatric in part of its range with P. albidum. Geographically sympatric with P. gracile but occupying a different habitat. Anthesis from early September to late October.

As one travels from west to east through southern Mississippi, Alabama and the panhandle of Florida, a gradient in anthesis time is apparent; the more easterly plants bloom several weeks earlier than the western populations.

Nomenclature and observations

Chapman, in presenting variety trifoliatus, separates it from the typical P. corymbosus on the following characteristics: 1.) it is glandless or nearly so; 2.) it possesses 3--4 broadly ovate, acute bracts; 3.) the style is ciliate below the middle; 4.) the petals are acute; and 5.) the leaves are "mostly" trifoliolate. To my observation, the two subspecies are indistinguishable in all the aforementioned characteristics except the last. Although Chapman did not cite a type or even a type locality, his numerous collections of this taxon (4-NY, 3-US, 3-MO) clearly indicate his understanding of it. I accept as a lectotype, his No. 6097, October 1897, Apalachicola, Florida (US 335288). A duplicate of this collection is at NY.

Gatesia alabamensis Bertol. was described from a plant

collected in Alabama and named in honor of the collector, Dr. Gates. The region of collection would indicate that it belonged in subspecies trifoliatum although the description does not indicate the leaflet number. A colored drawing following the article, plainly shows trifoliate leaves but a compound corymb. Throughout the range of subspecies trifoliatum, there are occasional individuals possessing compound corymbs. Their occurrence seems to have no geographic basis and they always possess trifoliate leaves. Assuming the accuracy of the artist, this is perhaps one of them. Since the type specimen was destroyed at Bologna during World War II (R. Savelli, pers. comm. 1964), this question may never be answered.

Gavesia appears to be merely an orthographic error, a substitution of a "v" for a "t." Walpers gives Bertoloni full credit for the original name but places it in synonymy.

II. Subgenus PETALOSTEMON Michx. Fl. Bor. Am. 2: 49. (1803)

Key to the Sections

1. Calyx glabrous throughout or villous ciliate on the lobes only (in P. occidentale and P. microphyllum puberulant overall); bracteoles usually present flanking the base of the calyces.
2. Mature stem leaves with 3--11 leaflets.

3. Calyx split dorsally to 1/2 its length; standard blade not lobed at base, the claw over twice as thick as the apical petal claws; limited in distribution to the southeastern United States.

A. Carnei page 80

3. Calyx not slit dorsally to 1/2 its length; standard blade basally lobed, the claw the same diameter as the apical petal claws; not limited to the southeast.

4. Corolla rose-purple; known only from New Mexico.

B. Prostrati page 125

4. Corolla white; not restricted as above.

C. Candidi page 130

2. Mature stem leaves with more than eleven leaflets.

5. Corolla rose-lavender, apical petals not strap shaped; restricted to Tennessee and Illinois.

D. Foliosi page 156

5. Corolla white, apical petals strap shaped; restricted to Texas and adjacent counties in Oklahoma.

E. Phleoides page 164

1. Calyx densely pubescent, at least on the angles and lobes; bracteoles lacking.

6. Stems and leaves spreading pubescent to villous; leaflets 11--21; all species restricted to sandy soils.

F. Villosi page 173

6. Stems and leaves glabrous to glabrate (spreading pilose in P. obovatum); leaflets 5--11 (13); not all species restricted to sandy soils.

7. Leaves solitary, seldom fascicled; leaflets broad elliptical to almost ovate, seldom involute; spikes often subtended by sterile bracts; fertile bracts with scarious margins; calyces spreading sericeous-pubescent.

G. Compacti page 181

7. Leaves fascicled; leaflets linear, involute; spikes not subtended by sterile bracts; fertile bracts seldom with scarious margins; calyces with short appressed or rarely spreading pubescence.

H. Purpurei page 207

A. CARNEI

Distinguishing characteristics

Plants glabrous except for pubescence on margins and inner surfaces of the calyx lobes. Leaflets 3--9 (11).

Peduncles usually interrupted by sterile bracts below the spikes. Calyces flanked by a pair of bracteoles arising laterally from the subtending bract; calyx tube slit dorsally more than one-half its length. Corolla white or pink, the standard claw over twice as thick as the apical petal claws. Flowering in mid or late summer.

Distribution

Restricted to extreme southeastern Louisiana, southern Mississippi and Alabama, Florida and Georgia.

Introduction

The southeastern species, Petalostemon gracile, P. albidum, P. carneum and P. feayi, represent a relatively homogeneous section of the genus Petalostemon. Limitation of their distribution to the southeastern coastal plain, and possession of common morphological characteristics strongly suggests that this complex evolved from common ancestry and speciated in situ. My evidence supports the thesis that the group consists of four species, that P. albidum might have arisen as a consequence of hybridization between P. gracile and P. carneum, and that introgression between P. albidum and P. carneum is currently taking place. The data provide an explanation for the variability that is found in these three species as compared to the relatively homogeneous P. feayi.

Ecology

Petalostemon gracile is limited to southern Mississippi, southern Alabama and the panhandle of Florida. It is commonly found in low grassy areas in association with uncut, long leaf pine (P. australis). On several occasions it was found growing in close proximity to Sarracenia bogs. It was never collected in disturbed habitats. P. albidum ranges down to Lee county in southern Florida and north-northwest into central Georgia. It is restricted to relatively dry, higher, often disturbed habitats -- cut over areas -- and particularly in association with turkey oak (Quercus laevis). It was in one such disturbed area that a "hybrid swarm" was found indicating introgression with P. carneum. P. carneum occurs throughout the Florida peninsula and southeastern Georgia. It is found in wet, low, undisturbed environments or in low areas where palmettos (Serenoa repens) have become the dominant vegetation. P. feayi is restricted to the white, dry sands of high pine woods, central Florida and southeastern Georgia.

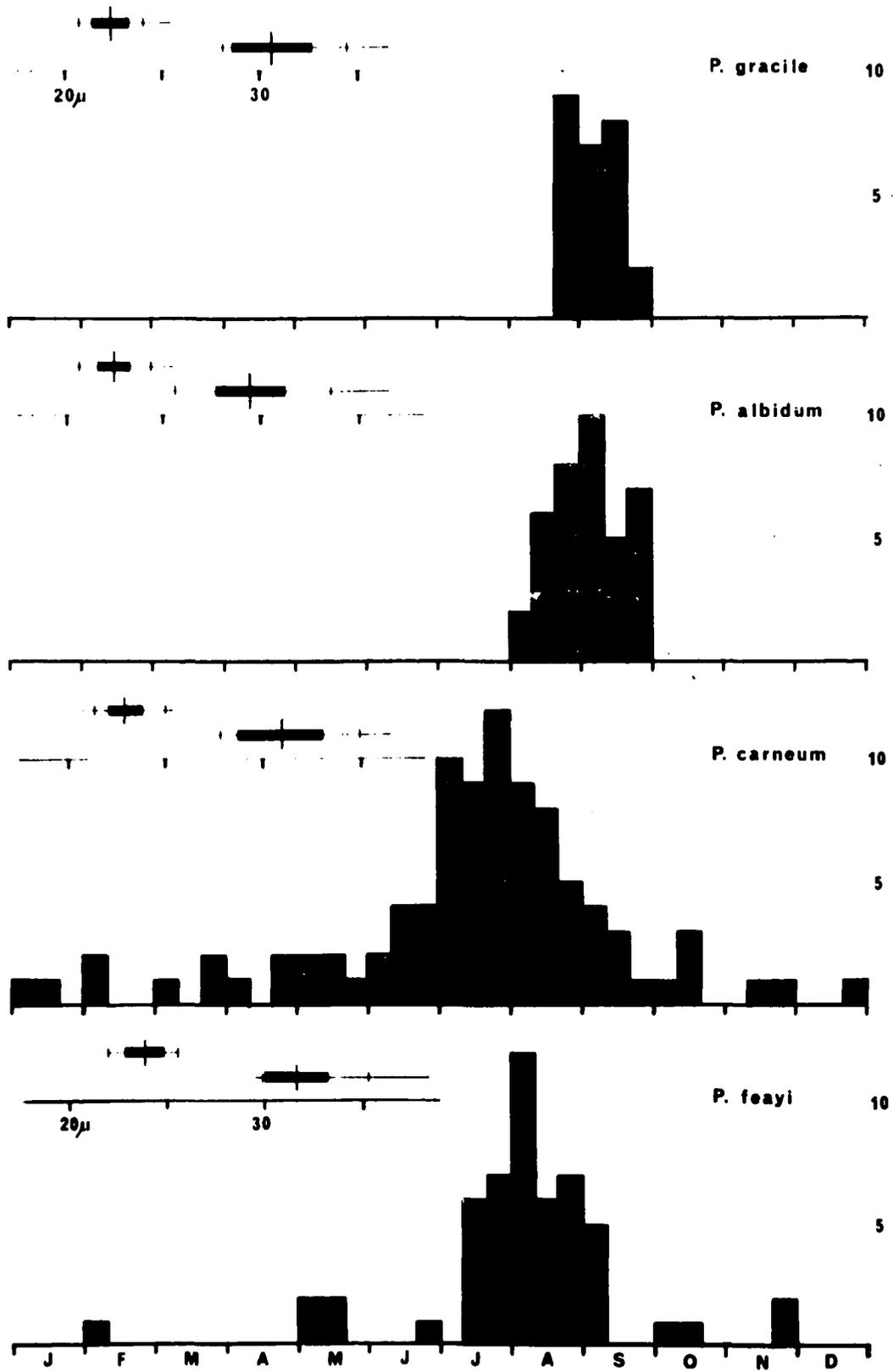
Intermediacy of the range of P. albidum between that of P. gracile and P. carneum as well as its preference for a "hybridized habitat" in comparison with the older habitats of the latter two species suggests the hypothesis of hybrid origin of P. albidum. Verification was sought in the anatomical analyses that follow.

Anthesis time

In considering the trio of species, P. gracile, P. albidum and P. carneum, (Fig. 27) P. gracile has a very short flowering period, P. albidum a somewhat longer one and P. carneum an extended one. This is partially dictated by the growth habit of the species as well as by the southern extension of the range of the respective species. The major stem of P. gracile rarely branches; hence, there is seldom more than one terminal flower spike for each shoot. Anthesis of all the spikes on a plant begins almost simultaneously and thus the flowering period is of short duration. P. albidum has moderate development of axillary branches; after the main apex has flowered, the lateral branches subsequently bloom. Axillary branching is the rule in P. carneum and often a "pseudo-corymb" is formed by axillary spikes which surround the terminal one. This is also the case in P. feayi.

Although southern range extension, which prolongs the blooming period of certain species by allowing a longer frost-free growing period is important, genetically controlled axillary branching is probably the predominant causal factor for lengthening the flowering period in this section of Petalostemon. Evidence for this is found in the fact that most northern collections of P. carneum have as long a blooming period as the southern collections and exhibit an equal amount of axillary branching.

Fig. 27. Phenology and pollen measurements in section Carnei. Duration of flowering (bar graphs) as interpreted from herbarium sheets. The ordinate represents the number of collections. The smallest square (■) is one collection. The abscissa represents the months of the year. Pollen measurements (upper left) are in microns. The upper line represents the width of the grains and the lower line, the length. Length of the fine line is the total range of variation for the species; the heavy line represents plus or minus one standard deviation; the central, larger vertical line is the arithmetic mean; and, the smaller, lateral marks represent the range of variation of sample averages



Cytology

Gametic chromosome number is uniformly $n = 7$ in the four species (Table 2, Fig. 22, A, C, F, H). While a determination on P. feayi has been previously reported (Turner 1963), those for the other three species are new. All counts were made from field collections and drawings were made of meiotic figures in pollen mother cells at pachytene, diakinesis, metaphase or incipient tetrad stages. Without exception, pairing was normal as was cytokinesis. Voucher specimens were deposited at ISC.

Pollen

Pollen size and shape proved valuable as diagnostic characters in other species of Petalostemon and data was obtained on the pollen of these southeastern species (Fig. 27). It is clear that pollen size and shape is of little value in separating these species; however, the similarity of the pollen is another indication of the closeness of their relationship.

Techniques for species determination

As a result of the familiarity gained during field work and herbarium study of the southeastern taxa, I sorted all the specimens into four stacks, each of which represented a putative species. I then analysed the character variations which allowed me to make such an intuitive separation. A

similar technique was utilized by Isely and Welsh (1960) in their study of P. candidum and P. occidentale. Their work differed to the extent that one individual utilized "taxonomic intuition" and the other, character analysis; thus avoiding possible "intuitive bias" when the analysis was conducted.

The material employed included 58 sheets of P. gracile representing 41 different collections, 80 sheets of P. albidum representing 52 collections, 183 sheets of P. carneum representing 127 collections and 109 sheets of P. feayi representing 72 collections. I chose 28 characteristics for study and from the data obtained, seven ratios were calculated. The characteristics were:

1. Stem striation.
2. Length of bracts on the peduncles.
- *3. Length of leaf rachis.
- *4. Length of subtending internode of #3.
- *5. Length of subapical leaflet.
- *6. Width of subapical leaflet.
- *7. Length of peduncle.
- *8. Length of inflorescence.
9. Width of inflorescence.
10. Degree of abaxial bending of bract tip.
- *11. Relative degree of axillary leaf clustering.
12. Presence of spherical secretory cavities ("glands") at the apex of the peduncle.
- *13. Degree of stem branching.

- *14. Growth habit.
- 15. Curvature of rachis and leaflets after drying.
- 16. Variation in stem ribbing below leaf.
- 17. Diameter of stem at base.
- *18. Length of bracts at anthesis.
- 19. Length of apical petal blade.
- 20. Length of apical petal claw.
- *21. Length of ventral calyx lobe.
- 22. Length of calyx tube.
- 23. Degree of bracteole pubescence.
- 24. Presence of bract "heel."
- *25. Degree of gynoecial pubescence.
- *26. Width of the standard.
- 27. Length of terminal rachis extension.
- *28. Exsertion of androecial sheath from calyx.
- 29. Maximum leaflet number.

Those characteristics with asterisks have been used by previous authors for distinguishing the species. However, the characteristics have been formerly used only in a generalized, comparative sense; they have not before been critically measured. The characteristics that are underlined were statistically analyzed. They were chosen because they showed distinctive means which distinguished the putative species. Before examining the analysis, each character deserves comment:

1. Stem striation

The degree of stem striation varied among these taxa. One-half of the P. gracile examined had smooth stems. Only a small proportion of the material of the other species lacked striate stems. Although an attempt was made to standardize the judgement of stem striation by observing the stem at a consistent distance from the base, the variations in striation patterns made objective analysis impossible. In general, the stems of P. albidum were coarsely striate, possessing less than ten major ribs around their circumference. The stems of P. carneum and P. feayi were usually finely striate possessing 15--25 low, rounded ribs.

2. Length of bracts on the peduncles

The bracts are not limited to the inflorescence proper but are, in part, scattered down the peduncle. These had never been used as characters in previous taxonomic treatments but I have found them most useful (Fig. 28, char. 2).

3. Length of leaf rachis, and

4. Length of subtending internode

A mature leaf, approximately one-third the distance from the stem base, was selected for measurement along with the internode immediately below it. Among the four species, there was significant variation in internodal length (Fig. 28, char. 4). P. feayi has the shortest internodes of the four species and P. gracile, the longest. This variation is seen in the more "leafy" appearance of the former species while P.

gracile appears to be mainly stems. The other two species are intermediate in internode length and intermediate in "leafy" appearance. All species possess essentially the same length leaf, averaging between 13.5 and 15.0 mm long. Both characteristics were combined in the analysis (Fig. 28, char. 3/4).

5. Length of subapical leaflet, and

6. Width of subapical leaflet

Utilizing the leaf previously measured, one of the pair of leaflets immediately below the apical leaflet was measured. A subapical leaflet was measured in preference to a terminal leaflet because the terminal leaflet is often broken off on specimens. Although not statistically analyzed, these data are shown in the ideographs (Fig. 31).

7. Length of peduncle

Peduncle length varied among the putative species. P. gracile usually had the shortest peduncles and P. albidum was intermediate in this characteristic between P. gracile and P. carneum (Fig. 28, char. 7).

8. Length of inflorescence, and

9. Width of inflorescence

The spike continues to elongate as flowering progresses; hence, spikes with one-half their flowers open were always chosen for measurement. The most useful combination of these two measurements proved to be the product of the inflorescence length and the inflorescence width, which in essence is the silhouette area of a spike (Fig. 28, char. 8/9

and 8 x 9). Among these species, P. carneum possessed the largest inflorescence.

10. Degree of abaxial bending of bract tip

This was a subjective character chosen as a result of field observation of these taxa. The spikes of P. gracile often possessed recurved bracts, the tips were sometimes pointing directly toward the base of the plant. Abaxial bending was sometimes found in the bracts of P. albidum but never in P. carneum. This characteristic was rated on a three step scale: full bending, partial bending, or bracts with straight tips. It appears in the numerical analysis as characteristic No. 10 (Table 5, Figs. 29, 30).

11. Relative degree of axillary leaf clustering

In common with most species of Petalostemon, inhibition of axillary meristematic regions is not complete. The result is axillary leaf "clustering" or "fascicular leaf development". This condition varies from essentially no visible clustering to the development of an entire, dwarf, axillary branch system, within which, each axil has further clustering. The resulting visual appearance of such a plant is one of extreme leafiness. This characteristic was rated subjectively in three categories: no leaf clustering, some leaf clustering and extreme leaf clustering. While P. gracile consistently lacks clustered leaves, other species showed no variation -- they all possess axillary leaf clustering.

12. Presence of spherical secretory cavities ("glands") at the apex of the peduncle

Specimens were placed in one of three subjective categories: those with no glands visible at the apex, those with some glands and those with numerous glands. In general, P. gracile lacks glands immediately below the inflorescence. Only 6 out of 41 specimens examined had glands. P. albidum and P. carneum usually possess glands but those of P. carneum are usually larger and more protuberant than those of P. albidum. The majority of the specimens of P. feayi examined lacked glands.

13. Degree of stem branching

P. carneum and P. feayi both exhibit extensive stem branching. In the former species, branching usually occurs in the upper half of the stem while in the latter species, branches arise below as well as above. Most P. albidum specimens examined were branched above, but there were also ones lacking branching, the plant composed only of primary stems. P. gracile is usually unbranched.

The determination of this characteristic depends, to a large extent, on the age of the plant. Greenhouse studies indicate that young stems will not branch until they have nearly reached their maximum length. At this time, axillary buds become active and elongate. Thus, a specimen of a young plant will not necessarily indicate its ultimate branching pattern.

14. Growth habit

Growth habit is difficult to determine from herbarium specimens. Even when the whole plant is present, it is often manipulated by the collector so as to make it a more aesthetically attractive specimen. Objectivity in designating a specimen prostrate, decumbent, or erect is difficult to achieve. Often a determination can be made by noting the diameter of the stem, the thicker-stemmed plants being erect in growth habit. Herbarium studies, complemented by field experience, can perhaps provide a reasonable estimate of the differential growth of the species.

P. gracile with its thin stems is prostrate with the tips of the branches weakly assurgent. Since it grows in grassy areas, it obtains some support from the surrounding grass. P. albidum is variable in growth habit, a variation that provided the first clue that it might have had a hybrid origin. Sometimes it is prostrate with assurgent peduncles similar to those of P. gracile. The other extreme is an almost erect plant, the stems supporting themselves and the inflorescence. P. carneum, with its thick stems is erect, P. feayi is also erect but the entire plant is often hemispherical in appearance, the outermost branches making an angle of about 45 degrees with the ground. Often a part of the lower stem is completely prostrate, even at times underground. In this case, axillary branches arise from this "rhizome," bearing spikes at their apices. The "rhizome" usually develops a periderm and

is corky in appearance.

15. Curvature of rachis and leaflets after drying

This is almost an exclusive characteristic of the leaves of P. carneum. Over one-half the specimens examined had the rachis and leaflets curved.

16. Variation in stem ribbing below the leaf

Three patterns were found in these species. The first is a complete lack of vertical ribbing immediately below the leaves: 45% of the P. feayi specimens and 20% of those of P. carneum. A second pattern is characterized by three vertical ribs below the leaves: 50% of the material of P. feayi, 75% of P. carneum, 80% of P. albidum and 15% of P. gracile. Thirdly, a single vertical rib was characteristic of 85% of the P. gracile specimens. From an external examination, these ribs appear to be vascular bundles from which the epidermis has shrunk in drying. The central rib is always below the leaf axis. The two lateral ribs, if present, are on the stipule axes.

17. Diameter of stem at base

The diameter was measured at the point where the stem emerges from the ground. It proved a valuable distinguishing feature of the four species (Fig. 28, char. 17).

18. Length of bracts at anthesis

Bract length has been used in almost all species of Petalostemon as a taxonomic characteristic. It must, however, be employed with caution because the bracts elongate during

anthesis. For example, mature bracts of P. gracile equal the calyx lobes at the base of the inflorescence but are shorter than the tube at the apex. This variation has apparently not been appreciated by previous authors. In an attempt to obtain consistency in determination, measurements were taken from spikes with one-half their flowers open and specifically, on bracts subtending flowers that had just undergone anthesis.

Bract length was found to be variable. P. gracile, P. carneum and P. albidum had bracts that varied in length from subequal to the calyx tube, to approximating or exceeding the lobes. On the other hand, the bracts of P. feayi are uniformly shorter than the calyx tube.

19. Length of apical petal blade, and

20. Length of apical petal claw

Total petal length, claw and blade inclusive, was similar for the four putative species -- approximately 3.5 mm for P. gracile, 3.7 mm for P. albidum, 3.8 mm for P. carneum and 3.9 mm for P. feayi. However, the relationship between the length of the claw and blade varied and proved valuable in the separation of the four taxa. P. gracile possesses the shortest petal blades and the longest petal claws, the two being almost equal in length. P. albidum possesses longer blades and relatively shorter claws, P. carneum even longer blades and shorter claws, and P. feayi the longest blades and shortest claws. A ratio of petal blade length to petal claw length was calculated for each of the specimens examined (Fig.

28, char. 19/20).

21. Length of ventral calyx lobe, and

22. Length of calyx tube

Calyx measurements have often been used as key characteristics in Petalostemon. To avoid ambiguity, I have chosen the base of the ventral lobe to be the dividing line between tube and lobe, and all lobe measurements are of the ventral lobe. Calyx lobe length, tube length and total calyx length (sum of lobe and tube length) are presented in Fig. 28, chars. 21, 22 and 21+22.

23. Degree of bracteole pubescence

All species showed varying degrees of bracteole pubescence ranging from glabrous to extremely pubescent except for P. feayi, the bracteoles of which were consistently pubescent.

24. Presence of bract "heel"

This characteristic proved valuable to Isely and Welsh (1960) in their study of P. candidum and P. occidentale. However, it appears to be of little value in differentiating among the species herein under consideration. P. gracile lacks a well developed heel. The other species exhibit varying degrees of heel development.

25. Degree of gynoecial pubescence

P. gracile and P. feayi possess only glabrous ovaries. Rarely a few long cilia at the base of the style are present. The ovaries of P. albidum and P. carneum are usually

pubescent; completely glabrous ovaries were not observed in P. albidum; about 25% were glabrous in P. carneum. Regardless of the degree of ovary pubescence, the style was consistently bearded in all species for at least the proximal one-third of its length.

26. Width of the standard

Standard width was characteristic of the species to the degree indicated in Fig. 28, char. 26.

27. Length of terminal rachis extension

The "rachis extension" is the length of rachis from the insertion of the petiolules of the distal pair of leaflets to the base of the petiolule of the terminal leaflet. This characteristic can be effectively used to separate P. gracile from the other species. P. gracile possesses an extension varying from 0.6--2.8 mm, whereas, the extension is short or lacking in P. albidum, P. carneum and P. feayi.

28. Length of extension of androecial sheath from calyx

The androecial sheath does not extend beyond the calyx lobes in P. gracile. It rarely exceeds the lobes in P. albidum and P. carneum (4% of the specimens of the former species and 10% of the specimens of the latter). Conversely, the androecial tube equalled or exceeded the calyx lobes in 85% of the specimens of P. feayi.

29. Maximum leaflet number

Leaflet number was determined for P. gracile, P. albidum and P. carneum. If used in conjunction with other

characteristics, leaflet number can be useful in the identification of species. The maximum leaflet number in P. gracile is usually seven or nine; 65% of the material examined possessed the lower number. Leaflet number of P. albidum varied from three to seven. Only 2% of the specimens possessed three; 74% possessed five and 24% possessed seven. The maximum number of leaflets of P. carneum ranged from five to eleven. The frequency was as follows: five, 6%; seven, 28%; nine, 48%; eleven, 18%.

The wide range of leaflet number in P. carneum is interesting because those specimens with the leaflet numbers of five and seven are mostly southern in distribution, while those having eleven leaflets are largely northern.

Analysis of measured characteristics

The characteristics which proved useful in separating the species of this section are graphically presented in Fig. 28.

The isolation of P. feayi from the trio of P. gracile, albidum and carneum is consistently shown in all the selected characteristics. Not only is the arithmetic mean of a given characteristic often quite different, but the variation is always less as is the standard deviation. I interpret this to indicate the homogeneity of P. feayi as well as its remoteness from the other species.

In each of the 12 characteristics, P. albidum is found to be intermediate between P. gracile and P. carneum, but in

Fig. 28. Graphical analysis of selected characteristics in section Carnei. The numbers used are those of characters underlined on pp. 87--88. The thin line represents the total range of variation; the thick line, \pm one standard deviation; and, the central cross mark, the arithmetic mean. G = P. gracile; A = P. albidum; C = P. carneum; F = P. feayi

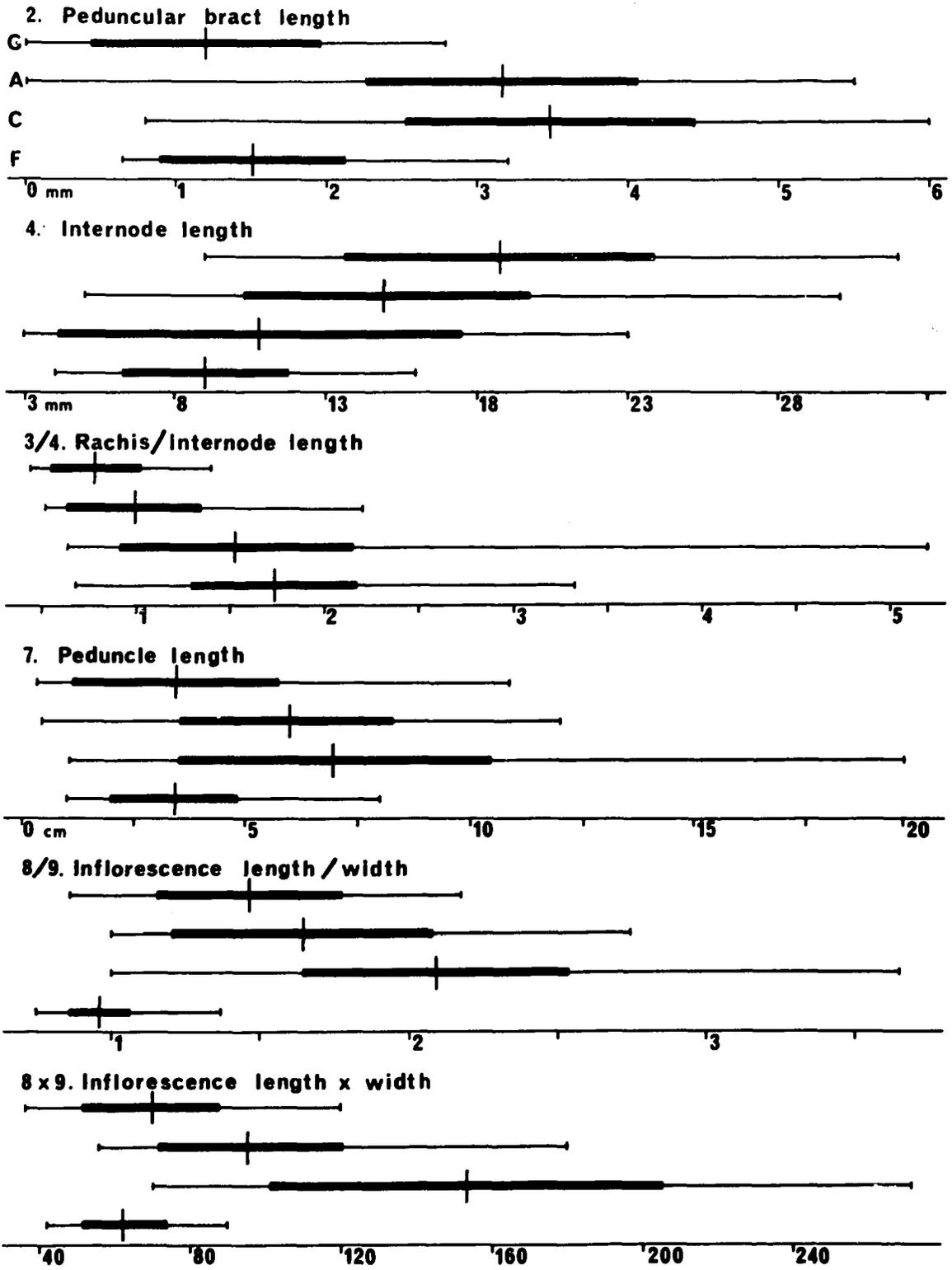
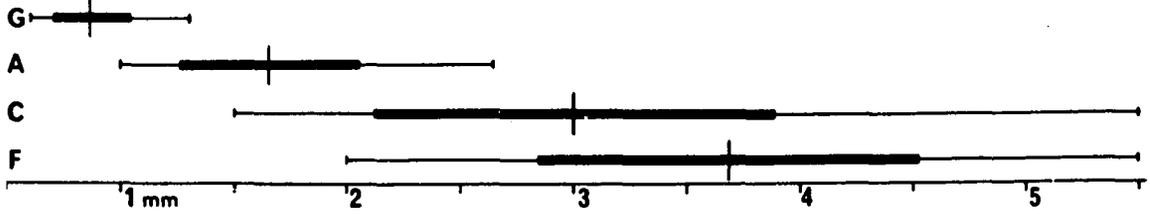
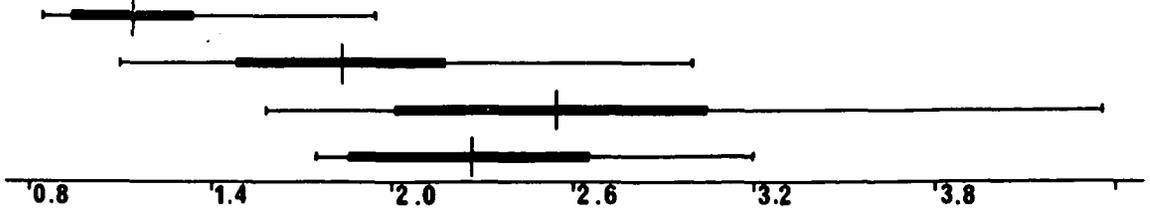


Fig. 28 (Continued).

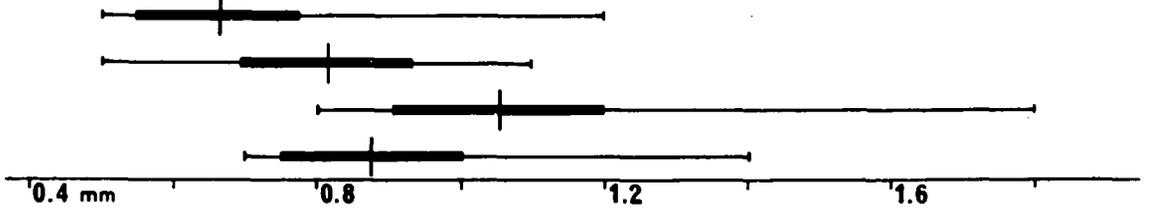
17. Stem thickness



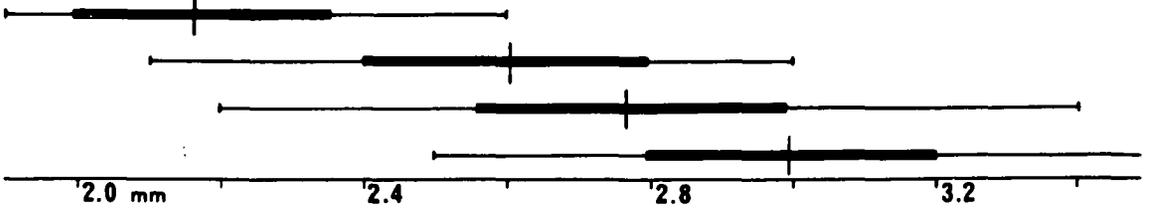
19/20. Petal blade/claw length



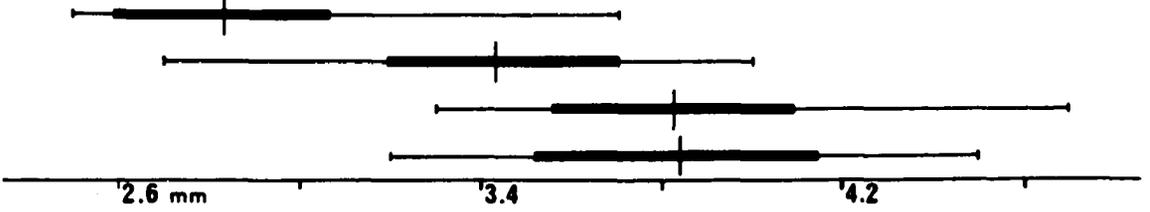
21. Calyx lobe length



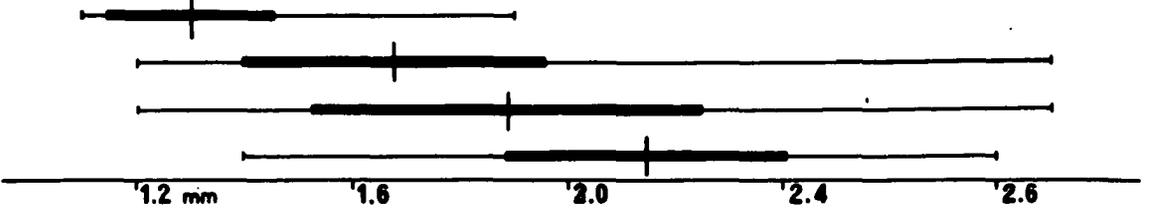
22. Calyx tube length



21 + 22. Total calyx length



26. Standard width



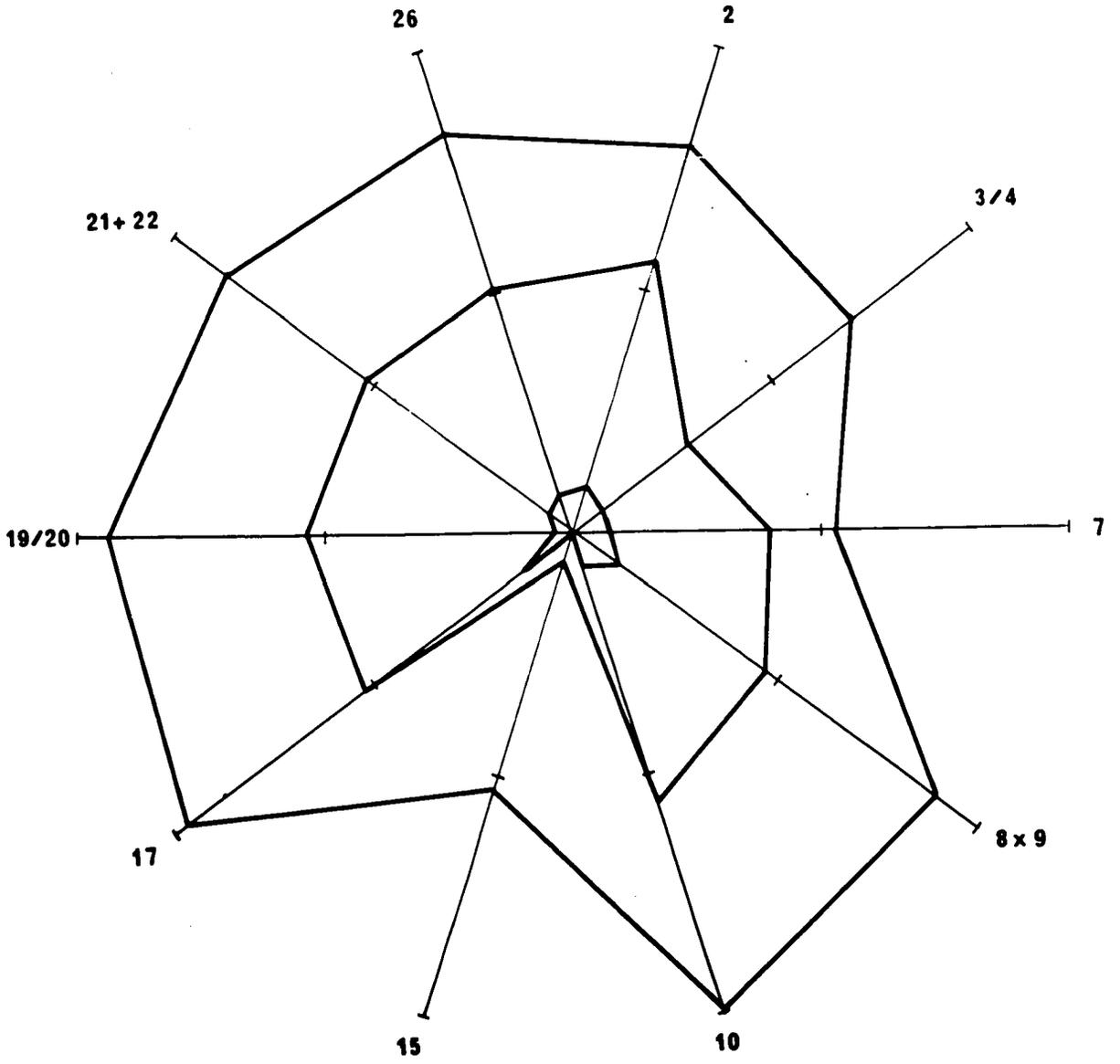
almost all cases, the ranges overlap as do the standard deviations. It is evident that no single characteristic can be used to differentiate between the three species. Multiple characteristics must be used.

Using the technique followed by Isely and Welsh (1960), each of the characteristics was standardized so that most of the P. gracile specimens would fall on one end of the scale and most of the P. carneum specimens at the other. This was accomplished by dividing the total range of variation shown by all species for each characteristic into three parts and assigning the numbers 0, 1, or 2 to each part respectively. The dividing points were subjectively chosen following examination of the rough data. In general, each range contains approximately one-third of the total number of specimens studied, with a correction factor added to allow for the disproportionate number of specimens of each of the putative species. The ten characteristics chosen for analysis together with their subdivision ranges is shown in Table 5. To avoid redundancy, some of the characteristics previously analyzed were eliminated. Average values for each of the ten are shown in the polygonal graph (Fig. 29). This graph reiterates the fact that P. albidum is intermediate in all characters. The values of all characteristics for each collection are then added producing a total "index" for each specimen or group of specimens from the same collection. This index would run from 0 for an

Table 5. Standardized, selected characteristics drawn from those listed on pp. 87-88. The total range of variation has been divided into 3 parts, arbitrarily numbered 0, 1, 2

Characteristics	Dividing points		
2. Length of bracts on peduncles	0	→ <	2.0 mm = 0
	2.0	→ <	3.5 mm = 1
	3.5	→	6.0 mm = 2
3./4. Ratio of length of leaf rachis to length of subtending internode	0.4	→ <	1.0 mm = 0
	1.0	→ <	1.5 mm = 1
	1.5	→	5.23 mm = 2
7. Length of peduncle	3.5	→ <	50.0 mm = 0
	50.0	→ <	80.0 mm = 1
	80.0	→	200.0 mm = 2
8.x9. Length of spike x width of spike	36.0	→ <	80.0 = 0
	80.0	→ <	125.0 = 1
	125.0	→	272.0 = 2
10. Abaxial bending of bract tip	Maximum bending		= 0
	Moderate bending		= 1
	No bending		= 2
15. Curvature of rachis and leaflets after drying	No curvature		= 0
	Partial curvature		= 1
	Full curvature		= 2
17. Thickness of stem base	0.6	→ <	1.1 mm = 0
	1.1	→ <	2.1 mm = 1
	2.1	→	5.5 mm = 2
19./20. Ratio of length of apical petal blade to length of petal claw	1.0	→ <	1.4 mm = 0
	1.4	→	2.0 mm = 1
	> 2.0 mm		= 2
21.+22. Total calyx length	2.5	→ <	3.1 mm = 0
	3.1	→	3.65 mm = 1
	> 3.65 mm		= 2
26. Width of standard	1.1	→	1.4 mm = 0
	1.41	→ <	1.8 mm = 1
	1.8	→	2.9 mm = 2

Fig. 29. Polygonal graph showing the average values for the characteristics enumerated in Table 5 for P. gracile (innermost line), P. albidum (middle line), and P. carneum (outer line). The center point of the graph is 0, the first cross mark is 1, and the peripheral cross mark is 2



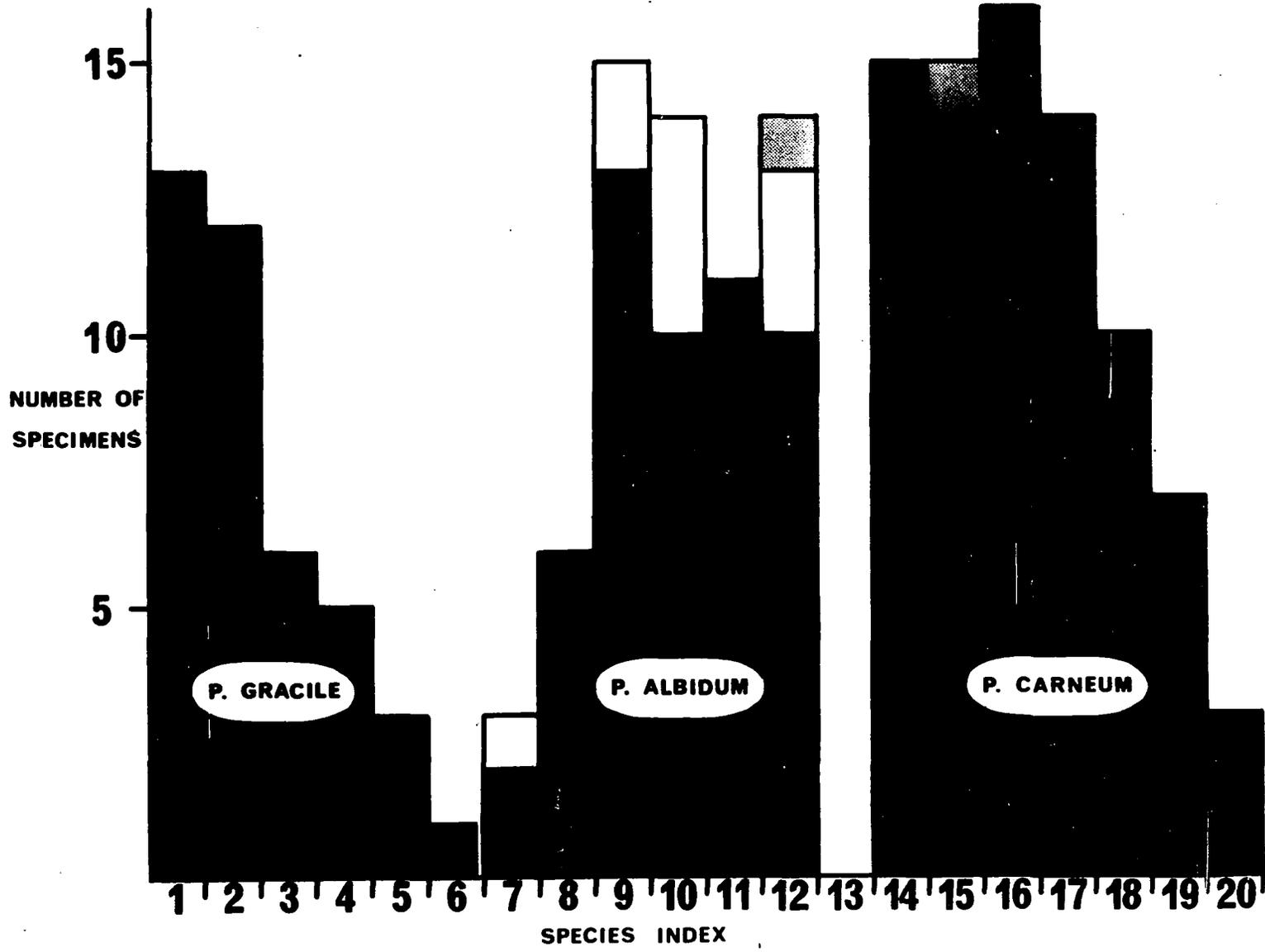
"ideal" P. gracile, to 20 for an "ideal" P. carneum. Fig. 30 shows the frequency of each of the index numbers in all the specimens studied. All the sheets tentatively identified as P. gracile showed a species index of 0--5, those identified as P. albidum 6--11, and those identified as P. carneum 13--20. There was no overlap in the index number between putative species. This clearly shows that while the three species in question cannot be differentiated consistently by a single characteristic, that by applying several, they are completely separated.

One collection deserves specific comment -- Isely and Wemple 9238M, 2 miles south of Old Town, Dixie county, Florida. The environment was a dry, sandy, disturbed area, probably an abandoned field -- a typical habitat for P. albidum. This particular population had every appearance of a classical "hybrid swarm." The growth habit of the plants ranged from prostrate-scrambling to almost erect and the flower color varied from white to pale pink. A mass collection was made and a species index calculated for each member of the collection (Fig. 30, the clear and stippled rectangles). The two individuals with an index, respectively, of 11 and 15, were pale pink in corolla color.

Summary

Four species are recognized in this southeastern complex. P. feayi is distinct from the other three on the basis of

Fig. 30. Species indexes computed for Petalostemon gracile, P. albidum and P. carneum. Based on the total of the ratings of the 10 characteristics enumerated in Table 5. The white and stippled rectangles represent specimens from the mass collection, Isely and Wemple 9238M. The two stippled squares represent specimens from this mass collection whose flowers were pale pink



several unique characters. The remaining three are differentiated easily by utilizing multiple characteristics. The intermediacy of P. albidum between P. gracile and P. carneum on all characteristics suggests that P. albidum is possibly of hybrid origin. Support for this hypothesis is also found in the habitat occupied by P. albidum -- disturbed areas, which possibly came into existence with the advent of man; the geographical distribution of P. albidum, intermediate between the putative parents; and, the discovery of introgressive populations. That P. feayi has not entered into active hybridization with the other three species is indicated by its uniformity in all measured characteristics.

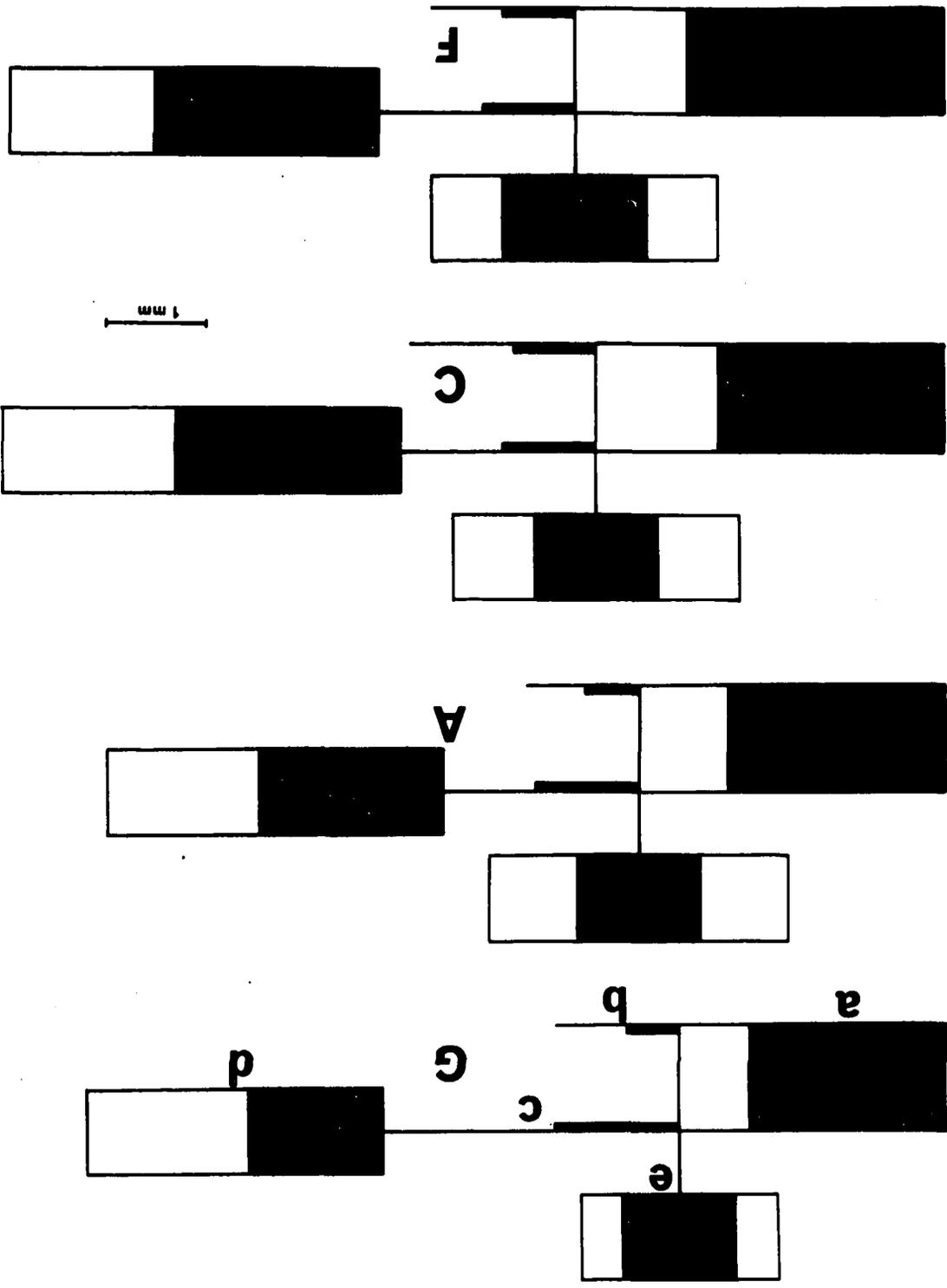
The ideograms (Figs. 31, 32) summarize vegetative and floral differences between the four species.

Key to the Species

1. Flowers white; ranging from southern Mississippi through the panhandle of Florida.
2. Stems weak, usually less than 1.1 mm thick at the base; leaves remote, not fascicled, leaflets 7--9, usually 2 mm or more wide, rachis extension beyond the apical pair, 0.8 mm or greater; peduncles short, usually less than 50 mm, with bracts less than 2 mm long; buds with bract tips recurved; limited to the Florida panhandle and southeastern Georgia, southern Mississippi and southern Alabama.

Fig. 31. Ideogram summary of vegetative and floral differences between Petalostemon gracile, G; P. albidum, A; P. carneum, C; and, P. feayi, F. Black areas represent minimum dimensions while the entire rectangles or lines represent maximum dimensions. a. length and width of spike; b. length of peduncle; c. length of peduncular bract; d. length of internode; e. length of leaf rachis; f. length and width of subapical leaflet; g. thickness of stem base

Fig. 32. Ideogram summary of the floral differences between P. gracile, G; P. albidum, A; P. carneum, C; and P. feayi, F. Black areas represent minimum dimensions while the entire rectangles or lines represent maximum dimensions. a. length of calyx tube; b. length of ventral lobe; c. length of apical petal claw; d. length of apical petal blade; e. width of standard blade



3. P. gracile p. 115

2. Stems stout, usually greater than 1.1 mm at the base; leaves close and fascicled, leaflets 5--7, usually less than 2 mm broad, rachis extension less than 0.8 mm; peduncles usually 50 mm or longer with bracts longer than 2 mm; buds with straight bracts; central and southern Georgia and the Florida peninsula.

4. P. albidum p. 119

1. Flowers pink; peninsular Florida and southern Georgia.
3. Spikes cylindrical; bracts longer than the calyx tube; anthers equalling petals at anthesis.

5. P. carneum p. 120

3. Spikes globose; bracts shorter than the calyx tube; anthers exerted beyond the petal apex.

6. P. feayi p. 124

3. PETALOSTEMON GRACILE Nutt. (Fig. 33)

Petalostemon gracile Nutt. Jour. Acad. Nat. Hist. Phil. 7: 92. (1834). Type in PH. (1)(2).

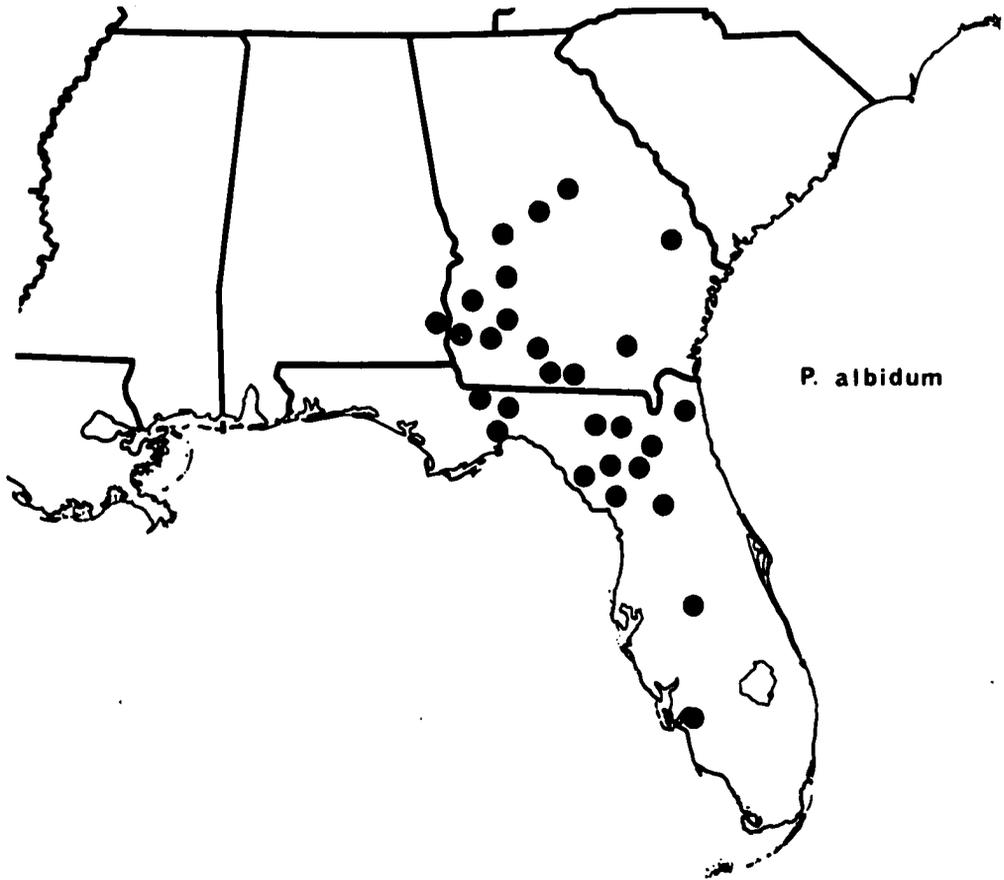
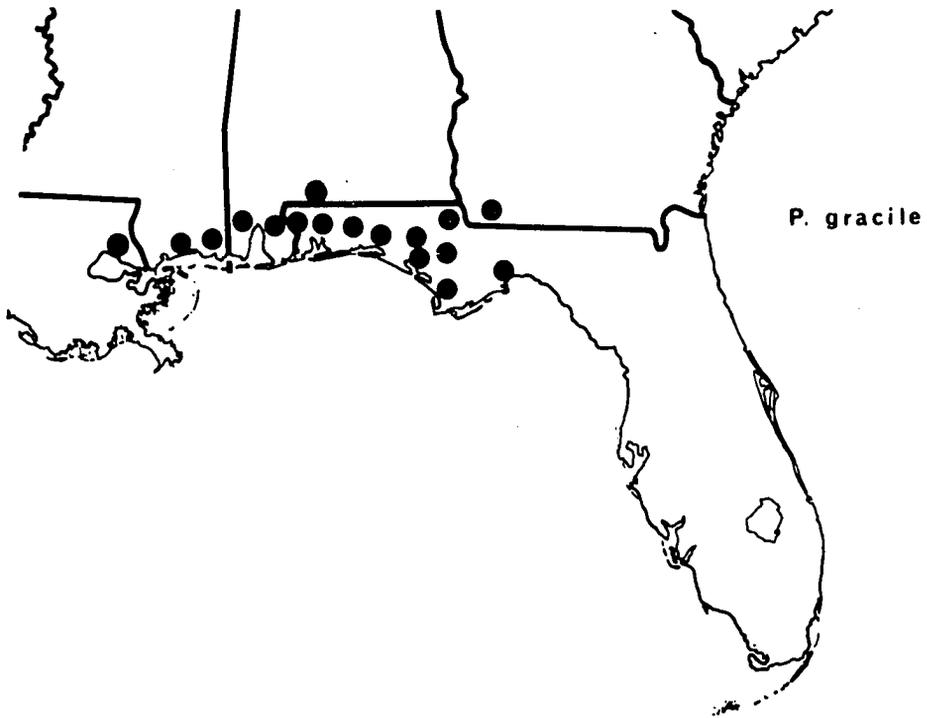
Petalostemum bicolor Bertol. Mem. Acad. Sci. Inst. Bologna 2: 273-274 + illus. pl. 13, f.1. (1850). (2).

Kuhnistera gracilis (Nutt.) Kuntze. Rev. Gen. Pl. 1: 192. (1891). Based on Petalostemon gracile Nutt.

Description

Root with strong napiform development from which radiate multiple, usually unbranched, weakly assurgent, usually non-striate stems, 3--6 dm long and 0.6--1.3 mm in diameter. Internodes at the middle of the stems 9--32 mm in length, usually longer than the leaves. Leaves solitary at the nodes, usually subtended by a single rib gradually fading basally into the round stem; rachis from 8--22 mm long, extending beyond the terminal pair of leaflets 0.7--2.8 mm. Leaflets on mature leaves 7--9, glabrous, 5.5--12.0 mm long, 1.2--3.8 mm broad, always less than 5 times as long as broad, elliptical to elliptical-oblongate. Peduncles 0.4--10.8 cm long, with sterile bracts up to 2.8 mm in length disposed at varying distances below the spikes. Spikes columnar, 6--15 mm long, 6--8 mm wide, about 1.5 times as long as broad. Bracts elliptical, equalling or slightly less than the lobes at anthesis, the tips usually recurved, a pair of subulate, often ciliate bracteoles arising from the base of each. Calyx tubular, split dorsally to more than one half its length; the tube 1.9--2.6 mm long, glabrous, glistening white, the rachis attachment point below the longitudinal calyx axis; ventral lobe 0.5--1.2 mm long, green, fleshy and pubescent on the inner surface and margins; glands apparent at the base of the lobes on drying. Corolla white, the standard shorter than the other petals and relatively narrow, the blade 1.1--1.9 mm wide, rounded at the apex; the claw 3--4 times as thick as the

Fig. 33. Geographic distribution of Petalostemon gracile
and P. albidum



claws of the apical petals. Apical petals uniform in shape, the two medial petals inserted lower than the two lateral petals; claws 1.2--2.9 mm in length; blades 1.3--2.9 mm long. Staminal tube not exerted beyond the calyx lobes, filaments shorter than petals, anthers yellow. Ovary always glabrous, style bearded proximally to 1/3--1/2 its length, predominantly on the lower surface.

4. PETALOSTEMON ALBIDUM (T. & G.) Small (Fig. 33)

Petalostemon albidus (T. & G.) Small Fl. SE. U. S. 630. (1903). Based on Petalostemon carneum β albidum T. & G.

Petalostemon carneum β albidum T. & G. Fl. N. Am. 311. (1838). Type in NY. (1)(2).

Petalostemon carneum of Ell. Bot. S. Carol. and Georgia. 2: 176. (1821-1824). (2). non P. carneum Michx. 1803.

Description

Stems numerous, prostrate to erect, 6--10 dm long, 1.0--2.6 mm in diameter, usually subtended by three ribs; leaf rachis 7--22 mm in length, extension beyond the terminal pair of leaflets less than 0.8 mm; leaflets 3--7, commonly 5, involute, 5--12 mm in length, 0.9--2.0 mm wide, usually about six times as long as wide. Peduncles 5--120 mm in length with pronounced glands at the apex; peduncular bracts to 5.5 mm in length. Spikes columnar, 8--22 mm long, 6--9 mm in width. Bracts equalling or exceeding the calyx lobes at anthesis, lanceolate, usually with straight tips, the base flanked by

subulate bracteoles. Calyx tubular, glabrous except for inner surfaces of the lobes, entire calyx 2.7--4.0 mm long, the tube 2.1--3.0 mm long and the ventral lobe 0.5--1.1 mm long. Corolla white; standard with claw 2--3 times as thick as apical petal claws, blade wider than apical petal blades, 1.2--2.9 mm wide; apical petals with blades 1.8--3.3 mm long, claws 1.0--1.9 mm long; claws about one-half the length of the blade. Androecial tube seldom exerted beyond lobes, anthers yellow, usually equalling the petal apices following anthesis. Ovary always ± bearded, the style bearded proximally from one-third to more than one-half its length.

5. PETALOSTEMON CARNEUM Michx. (Figs. 34; 51D, 1-3)

Petalostemum carneum Michx. Fl. Bor. Am. 2: 49. (1803).
Type in P. (1)(2).

Psoralea carnea (Michx.) Poir. in Lam. Encycl. 5: 694.
(1804). Based on Petalostemum carneum Michx.

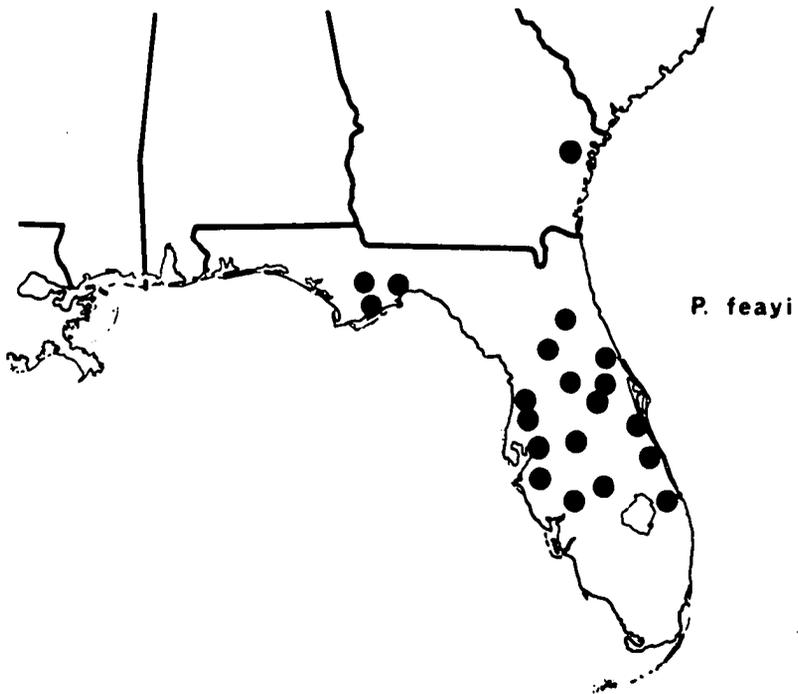
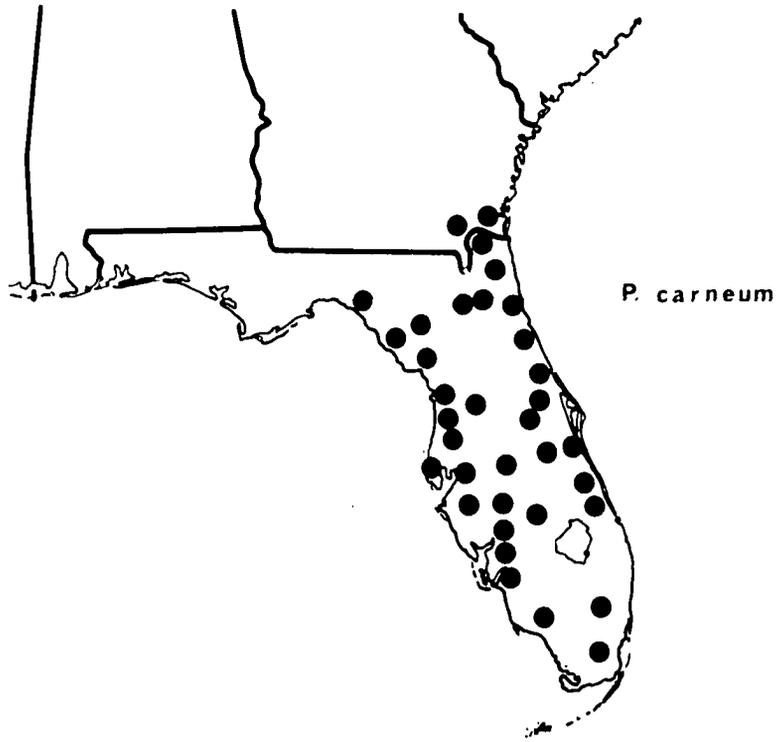
Dalea carnea (Michx.) Poir. Dict. Sci. Nat. 12: 462.
(1818). Based on Petalostemum carneum Michx.

Petalostemon roseum Nutt. Am. Jour. Sci. 5: 298. (1822).
Type in GH. (1)(2).

Kuhnistera carnea (Michx.) Kuntze. Rev. Gen. Pl. 1: 192.
(1891). Based on Petalostemum carneum Michx.

Kuhnistera rosea (Nutt.) Kuntze. Rev. Gen. Pl. 1: 192.
(1891). Based on Petalostemon roseum Nutt.

Fig. 34. Geographic distribution of Petalostemon carneum
and P. feayi



Description

Stems many, erect, 5--10 dm long, fine-striate, usually branched above, 1.5--5.5 mm thick; internodes 3--23 mm long. Leaves fascicled, the rachis 6.5--23.0 mm long, often curving when dried, extending less than 0.8 mm beyond the terminal pair of leaflets; leaves subtended by three stem ribs, or ribs lacking -- never a single rib; leaflets 5--11, usually 9, moderately involute, 5--11 mm long and 1--3 mm wide, usually about five times as long as wide. Peduncles from 11--200 mm long, usually glandular at the apex; peduncular bracts subulate, 0.8--6.0 mm long. Spikes columnar, 10--31 mm long and 7--10 mm wide. Bracts usually equalling lobes at anthesis, lanceolate with straight tips, their base flanked by subulate bracteoles. Calyx tubular becoming strongly ribbed upon drying, glabrous except for inner surfaces of the lobes and their margins, entire calyx 3.3--4.7 mm long, the tube 2.2--3.4 mm long and the ventral lobe 0.8--1.8 mm long. Corolla pink; the standard blade orbicular, emarginate and wider than the apical petal blades, 1.2--2.9 mm wide, the claw twice as thick as the claws of the apical petals; apical petal blades 1.9--3.9 mm long, the claws 0.7--1.7 mm long, less than one-half the length of the blade. Androecial tube often equalling the calyx lobes; anthers extended, equalling the length of the petals, yellow-orange at anthesis. Ovary usually bearded or at least slightly pubescent; style bearded proximally from one-third to more than one-half its length.

6. PETALOSTEMON FEAYI Chapm. (Figs. 34; 51D, 4)

Petalostemon feayi Chapm. Fl. S. U. S. ed. 2. 615.
(1883). Type in US. (1)(2).

Kuhnistera feayi (Chapm.) Nash. Bull. Torr. Bot. Club 22:
149. (1895). Based on Petalostemon feayi Chapm.

Description

Stems numerous, 2--6 dm long, arising from a horizontal rootstock or caudex; the central stems erect, the peripheral ones reclining, the whole often forming a hemispherical clump; the lower portions of the stems often with a corky exterior, the upper portions branching, finely striate or smooth; internodes 4--16 mm long. Leaves fascicled, rachis 8--22 mm long, often curved when dried, extension beyond the terminal leaflet pair always less than 0.8 mm; ribs below leaves often lacking or three in number. Leaflets on mature leaves 7--9, usually 7, filiform, involute, often curved when dried, 5--13 mm long and 0.5--1.4 mm broad, usually ten times as long as broad. Peduncles 10--80 mm long, usually lacking glands at the apex; sterile peduncular bracts 0.8--3.2 mm in length. Spikes globose, 6--11 mm long and 7--10 mm wide, the lower flowers declined. Bracts shorter than the calyx tubes, narrowly lanceolate, strongly keeled, flanked at the base by a pair of narrowly lanceolate bracteoles. Calyx tubular, slightly gibbous dorsally, glabrous except for a slight ciliation on the inner surfaces of the lobes, 3.2--4.5 mm long, the tube 2.5--3.5 mm long and the ventral lobe 0.7--1.4

mm long. Corolla pink, rarely white; the standard wider than the apical petals, orbicular, 1.4--2.8 mm wide, the claw 3--4 times as thick as the apical petal claws; blades of the apical petals 2.2--3.6 mm long, the claws 0.9--1.8 mm long, about one-half the length of the blade. Androecial tube almost always exerted beyond the calyx lobes, the anthers exerted beyond the apices of the petals, orange at anthesis. Ovary globular, glabrous, the style lightly pubescent proximally to one-half its length, occasionally glabrous.

B. PROSTRATI

Distinguishing characteristics

Stems prostrate, glabrous, covered with reddish-brown, spherical glands; leaflets glabrous, cuneate-obovate; spikes sessile, becoming lax in fruit; bracts broad and glabrous with scarious and ciliate margins, early deciduous; paired bracteoles present; calyx glabrous except for ciliate lobes, prominently glandular between the calyx ribs, the tube split dorsally to over one-third its length; corolla rose-purple, standard broad-cordate.

7. PETALOSTEMON PROSTRATUM Woot. & Standl. (Fig. 35)

Petalostemon prostratum Woot. & Standl. Contr. U. S. Nat. Herb. 16: 138. (1913). Type in US. (1)(2).

Description

Stems prostrate, 2--6 dm long, round at the base becoming striate toward the apex, straw-colored, glabrous, covered with reddish-brown, spherical glands. Stipules subulate, 2.5 mm long or less, often curved. Leaves glabrous, solitary; leaflets 7--9 (11), inserted in the distal one-half of the rachis, 6 mm long, 3 mm wide, cuneate-obovate, finely gland-dotted below. Spikes sessile, 35--90 mm long, 8--9 mm wide, becoming lax in fruit. Bracts glabrous, margins scarious, ciliate, 2.5 mm broad, precocious, exceeding the calyx lobes in bud, equalling them immediately prior to anthesis, then deciduous, leaving a prominent heel on the glabrous rachis. Paired, pubescent bracteoles flank the calyx, 1.3 mm in length. Calyx tube glabrous, 3.2 mm long, slightly ten-ribbed, with 3--7 protuberant, yellow, pellucid glands lying between the ribs, each gland 0.2--0.3 mm long and 0.1 mm wide; tube slit dorsally to over one-third its length, the margin of the slit ciliate; lobes lanceolate, short-ciliate at the margins and on the inner surfaces, the ventral lobe 1.3 mm long. Corolla rose-purple; standard suborbicular, strongly lobed at the base, 4 mm broad, 2.8 mm long; the apical petals 3.5--3.7 mm long, 1.2--2.0 mm broad, the claws 0.7 mm long. Androecial tube not exerted beyond the calyx lobes at anthesis. Ovary 1.8 mm long, 1 mm in diameter, slightly ciliate on the distal portion; style ciliate dorsally only at its proximal end, 8 mm long. Pod not exerted beyond the calyx lobes, slightly

ciliate at the distal end.

Distribution and phenology

Albuquerque and Belen, New Mexico. Known only from these two locations in Bernalillo and Valencia counties. Maximum flowering time probably late August.

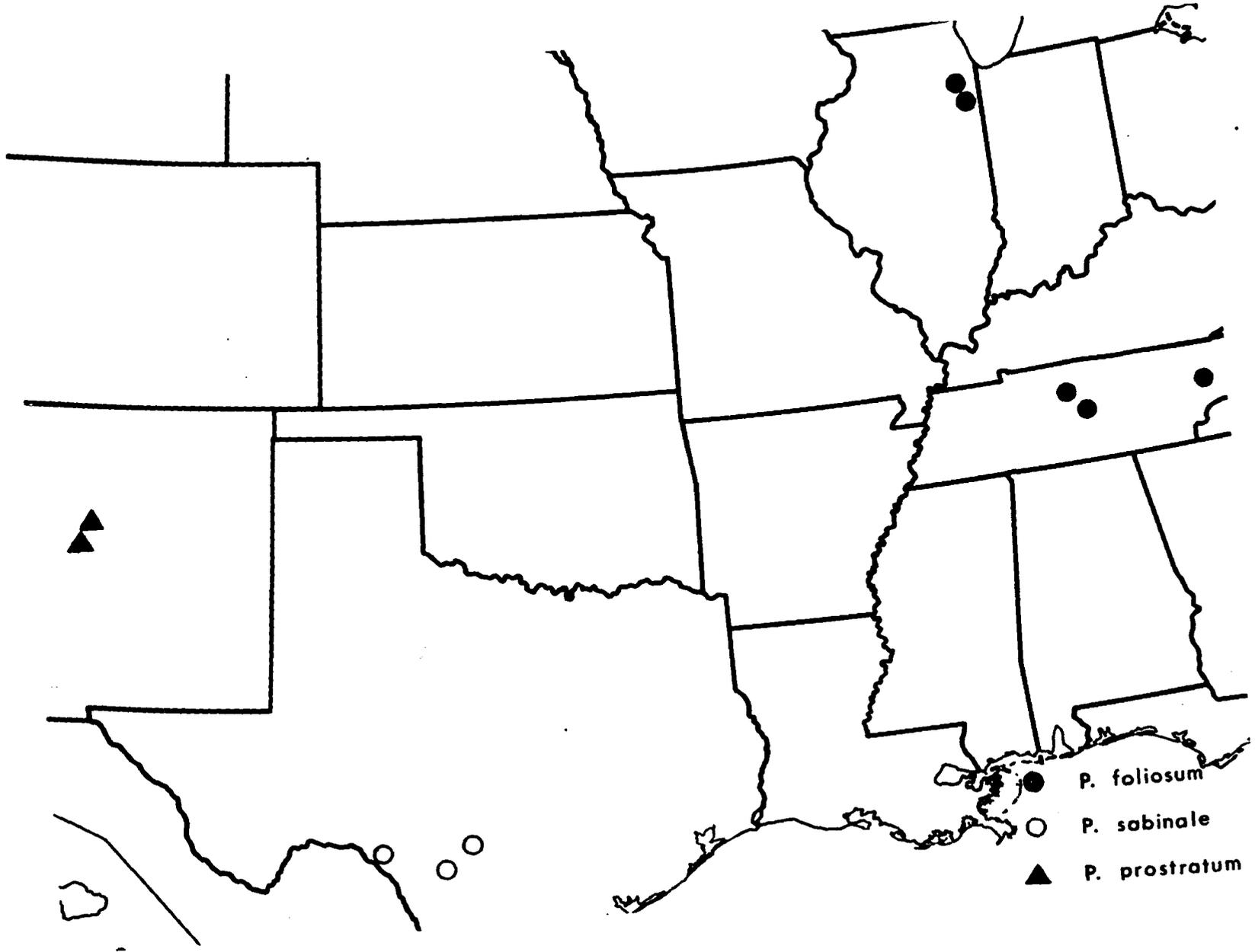
Observations

I have studied the type specimen (Winnie Howard 17 Albuquerque, New Mexico, 1900) and two other collections from the same locality (Rusby 6 September 1909; Rusby 8 September 1909). Wootton and Standley cite another specimen (Wootton 1 August 1906 Belen, New Mexico). To my knowledge these are the only collections of this species.

P. prostratum is very distinctive but shares many characteristics with P. foliosum and P. sabinale, viz.: glabrous stems, leaves and calyx tubes; paired bracteoles flanking the calyces; deeply, dorsally-slit calyces and lavender to pink corollas. The calyx glands of P. prostratum are similar in size, shape and color to those of P. sabinale. It is noteworthy also that all three species are restricted endemics, although widely separated geographically.

However, P. prostratum differs from the other two species in several features, among them: 1) prostrate growth habit; 2) lower leaflet number and obovate leaflets; 3) wide bracts with prominent, scarious margins; 4) suborbicular, prominently

Fig. 35. Geographic distribution of P. foliosum, P. sabinale and P. prostratum



lobed standard with a narrow claw; and 5) an elliptically shaped ovary. Therefore, I have not included P. prostratum in the Foliosi. Probably it is related to that group, but not to the same degree that P. foliosum and P. sabinale seem to be associated.

In the description of the species, the authors state the stamen number to be six. In all flowers that I have examined, the stamen number was five.

C. CANDIDI

Distinguishing characteristics

Stems glabrous; paired bracteoles, arising from the calyx attachment point on the rachis flanking each calyx; calyx not inflated, \pm strongly ten-ribbed, glabrous to slightly pubescent, the tube white, the lobes green with prominent glands at their base between the calyx nerves; corolla white, the standard strongly lobed basally and the claw the same diameter as the apical petal claws; ovary with characteristic teardrop-shaped glands on the proximal lateral surfaces.

Distribution and ecology

Wide ranging through the tall grass prairies of the central United States, southern Canada, across the short grass plains to the Rocky Mountains and south to Arizona, northern Mexico and Texas. Apparently adapted to a wide range of soil

types; calcareous prairie soils, rocky limestone soils, clays and sands.

P. candidum, occupying the tall grass prairies of the central United States and Canada, is gradually replaced to the west by P. occidentale and to the south by P. multiflorum. Ecological sympatry occurs, however, only between P. candidum and P. multiflorum. All three species are interfertile, but allopatry and spatial separation of populations are probably important factors limiting hybridization. Of the three, P. multiflorum is distinctive and easily recognized, whereas there has been little agreement among botanists regarding the characterization of the other species. Isely & Welsh (1960) reviewed the controversy in detail, illustrating how, with multiple characteristics, the two species may be delimited. The work is summarized by Isely (1962).

Key to the Species

1. Leaflets 9--13 (5 on depauperate specimens), uniform over the entire stem; spikes globose to ovoid, less than 1.5 cm long, entire inflorescence corymbose; bracts shorter than the calyx tube in bud and scarcely exceeding the tube at anthesis.

8. P. multiflorum p. 132

1. Leaflets 5--9; lower leaves often with larger leaflets than upper ones; spikes cylindrical, usually exceeding 1.5 cm, not corymbosely arranged; bracts exceeding calyx lobes in bud equalling or exceeding them at anthesis.
2. Rachis elongating in fruit, separating calyces; calyx usually finely puberulous, strongly ten-ribbed.

9. P. occidentale p. 137

2. Rachis not elongating, calyces remaining close together even in fruit; calyx glabrous, ten-ribbed but with rounded ridges.

10. P. candidum p. 149

8. PETALOSTEMON MULTIFLORUM Nutt. (Figs. 36, 51C)

Petalostemon multiflorum Nutt. Jour. Acad. Nat. Sci. Phil. 7: 92-93. (1834). Type in PH. (1)(2).

Kuhnistera multiflora (Nutt.) Heller. Mem. Torr. Bot. Club 5: 197. (1894). Based on P. multiflorum Nutt.

Kuhnistera candida multiflora (Nutt.) Rydb. Cont. U. S. Nat. Herb. 3: 154. (1895). Based on P. multiflorum Nutt.

Description

Plants with coarse, black root system terminating in a woody caudex, occasionally with short rhizomes. Stems many, 3--8 dm long, the central ones erect, the lateral ones almost horizontal often giving a hemispherical appearance to the entire plant; stems glabrous, round when fresh, drying striate above, pale straw color with prominent yellow to red glands;

much branched, especially in the upper one-half of the stem, the uppermost flowering branches usually leafless. Stipules lance-subulate, 1--2 mm long, chartaceous, usually fugacious. Mature leaf rachis 5--15 (25) mm long, never extended beyond the terminal pair of leaflets more than 0.5 mm. Leaflets (5) 7--13, linear-oblong or linear-oblongate, often obtuse or mucronate, 6--14 mm long and 2--3 mm wide; prominently gland-dotted only on the lower surface. Flowers disposed in numerous, short, usually globose spikes, 8--12 (25) mm long and 8--10 mm thick, terminating the many upper branches of each main stem. Spike subtended by a whorl of sterile bracts that persists even after fruits fall from the rachis; fertile bracts never exceed the calyx lobes in early bud and are usually shorter than the calyx tube at anthesis, 2.0--2.4 mm long, early deciduous, leaving a prominent "heel" on the rachis. Lance-subulate, ciliate, bracteoles arise laterally and abaxially from the calyx attachment point on the rachis in close proximity to the "heel," 0.1 mm wide at the base, 1.4--1.8 mm long. Calyx tube white, the base suffused with pink, drying straw-colored and strongly ten-ribbed, 2.2--2.6 mm long, 1.6--2.0 mm high; lobes green, deltoid, ciliate on margins, 1.0--1.4 mm long, terminating in a gland; prominent bronze glands between ribs at the base of the lobes. Corolla white, persistent, the standard suborbicular, deeply lobed at the base, 3 mm broad, 2.0--2.8 mm long, the claw 3 mm long; apical petals oblong, 2.2--2.8 mm long, 1.4--1.8 mm broad, the

claw 1.3--1.6 mm long. Androecial tube equalling the calyx lobes at anthesis; filaments white; anthers pale yellow, slightly exserted beyond petals. Ovary 1.3 mm long, 0.7--0.8 mm in diameter, slightly ciliate dorsally, otherwise completely glabrous; 4--6 teardrop shaped protuberant glands are located proximally on the sides of the ovary, the largest above, the remainder decreasing in size below; pellucid when fresh, drying bronze: style glabrous, inserted on the carpel axis, equalling or slightly exceeding the anthers at anthesis. Pod exserted from calyx in fruit, the beak directed upward from the calyx axis. All parts of the plant producing a pungent odor when crushed.

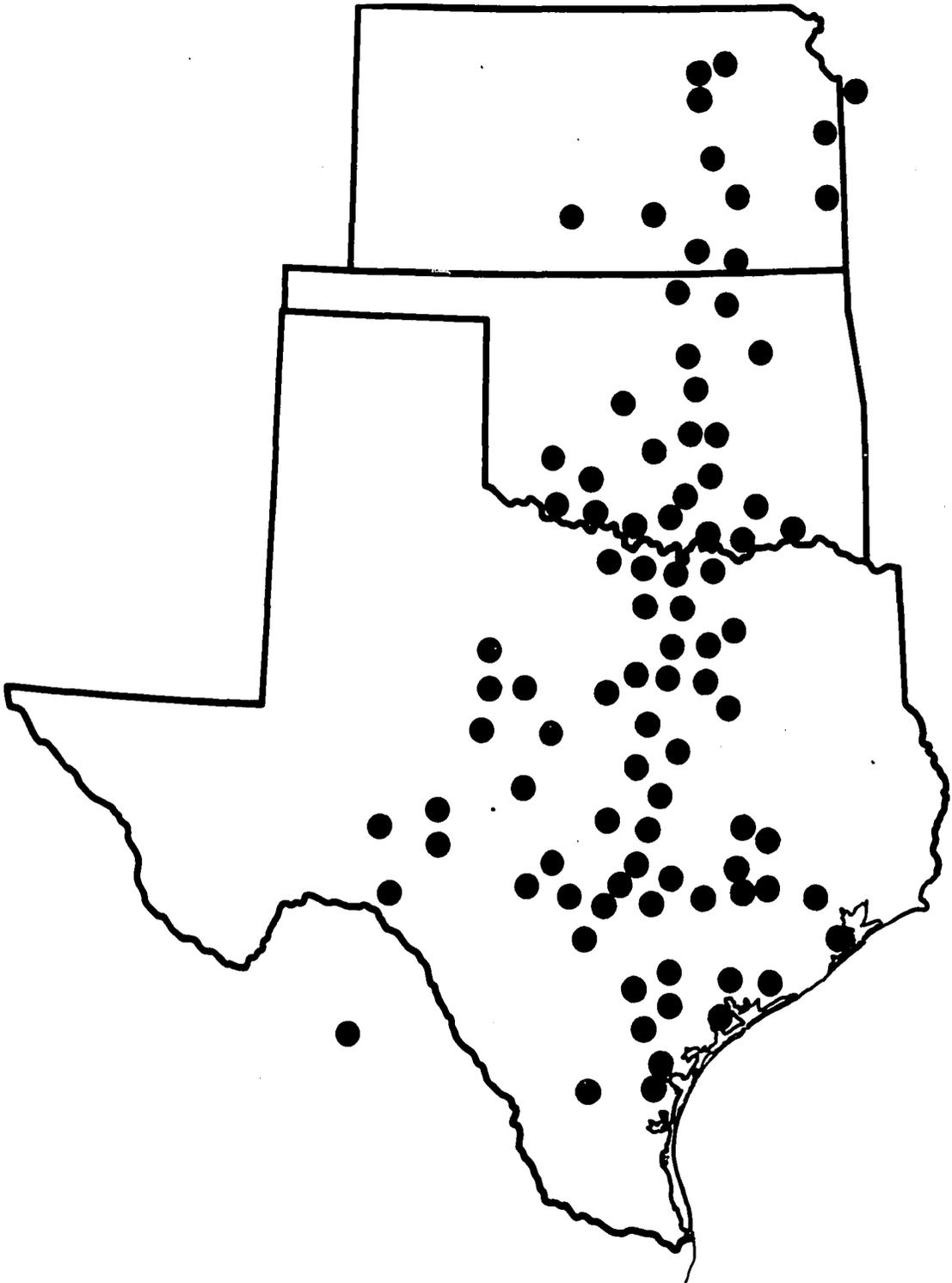
Distribution and phenology

Eastern Kansas south through central Oklahoma, central and central-eastern Texas; one collection in Chihuahua, Mexico. Limited to relatively dry, rocky prairies. Flowering begins in mid May for the south Texas populations, mid June for those in Oklahoma and mid July for those in Kansas, concluding in early August.

Observations

This species is usually readily distinguished from P. candidum and P. occidentale by the possession of many globose spikes arranged in a corymbose manner and uniform leaves with 9--13 leaflets. Geographically, the range overlaps both with

Fig. 36. Geographical distribution of P. multiflorum



P. candidum and P. occidentale but, from my field experience, ecological sympatry occurs only with P. candidum. Although I have never seen these species growing in close proximity, there is evidence indicating occasional hybridization between the two. The putative hybrids possess elongated spikes and have bracts exceeding the calyx tubes, sometimes equalling the lobes at anthesis. The elongate spikes are terminal, whereas, the lateral spikes (those producing the corymbose pattern, characteristic of P. multiflorum) are often more globose. Two such collections are from the zone of sympatry: Wemple 396, Cotton Co., Oklahoma, (ISC); and Sizemore 270, Osage Co., Oklahoma, (OKLA). In both, spikes up to 25 mm long are common. These characteristics are matched by hybrids between P. candidum and P. occidentale I have synthesized in the greenhouse.

9. PETALOSTEMON OCCIDENTALE (Gray ex Heller) Fernald (Figs. 38, 51B)

Petalostemum occidentale (Gray ex Heller) Fernald
Rhodora 39: 28. (1937). Based on Kuhnistera occidentalis
Heller.

? Petalostemum virgatum Nees von Esenbeck in Wied-Neuw.
Reise Nord-Am. 2: 432-433. (1840). (2).

Petalostemon gracile Gray. Mem. Amer. Acad. II 4: 33.
(1848). not P. gracile Nutt. (1)(2).

Petalostemon gracile var. oligophyllum Torr. in Emory,
Notes Mil. Recon. Ft. Leavenworth -- San Diego. 139.
(1849). Type in NY. (2).

Kuhnistera occidentalis Gray ex Heller. Trans. N. Y. Acad. Sci. 14: 33-34. (1894). Based on "Petalostemon candidus var. occidentalis Gray," unpublished name on Pringle labels. (1)(2).

Kuhnistera candida occidentalis Rydb. Contrib. U. S. Nat. Herb. 3: 154. (1895). Type material in NY. (1)(2).

Kuhnistera candida diffusa Rydb. Fl. Neb. 59. (1895). Type material in NY. (1)(2).

Kuhnistera oligophylla (Torr.) Heller. Bull. Torr. Bot. Club 23: 122-123. (1896). Based on P. gracile var. oligophyllum. Torr. in Emory.

Petalostemon oligophyllum (Torr.) Rydb. Mem. N. Y. Bot. Gard. 1: 237-238. (1900). Based on P. gracile var. oligophyllum. Torr. in Emory.

Petalostemon truncatus Rydb. Fl. N. Am. 24: 124-125. (1919-1920). Type in NY. (1)(2).

Petalostemon sonorae Rydb. Fl. N. Am. 24: 125. (1919-1920). Type in NY. (1)(2).

Petalostemon candidum var. oligophyllum (Torr.) Hermann. Jour. Wash. Acad. Sci. 38: 237. (1948). Based on P. gracile var. oligophyllum. Torr. in Emory.

Description

Stems several, branching above, decumbent to erect, glabrous, 4--8 dm long; coarsely striate, often drying a glaucous, pale green. Stipules 3.0--4.5 mm long, drying brown, fragile. Mature leaf rachis, 10--20 (30) mm long bearing 5--7 (9) glabrous, gland dotted, elliptical-oblong or oblanceolate, often emarginate, involute leaflets, 5--10 (15) mm long, 2--4 (5) mm wide; often with larger leaflets at the base of the plant; the leaflet midrib is usually not prominent on the lower surface. Flowers disposed in a columnar spike which becomes

lax in fruit, 6--8 mm wide and up to 70 mm long; occasionally with a few short, sterile bracts at varying distances below the spike. Fertile bracts exceeding the calyx lobes in bud, deciduous prior to anthesis, usually leaving a short "heel" on the rachis. Bracteoles filiform, 1--2 mm long, slightly ciliate, inserted beside calyx attachment point on rachis, quite separate from the bract "heel." Calyx tube white, strongly ten-ribbed drying sharp-ribbed, not round-furrowed as in P. candidum; usually + pubescent between ribs, 2.3--2.9 mm long, 1.6--2.0 mm in diameter; lobes green, deltoid-lanceolate, ciliate at margins, the ventral lobe 1.0--1.3 mm long; prominent glands at base of lobes between ribs of calyx tube, drying bronze. Corolla white, standard 2.6--3.3 mm broad, 1.8--2.2 mm long, lobed at base, the claw 3.0--3.5 mm long; apical petals elliptical-oblong, 2.5--3.0 mm long, 0.9--1.4 mm wide, the claw 1.1--1.3 mm long. Staminal tube exerted beyond calyx lobes at anthesis; anthers not extended to petal tips, pale yellow, drying yellow-brown. Ovary glabrous save for ciliate fringe on dorsal surface, 1.3--1.7 mm long, 0.8--1.0 mm in diameter; style glabrous, inserted slightly above carpel axis, 8--10 mm long, exceeding the petal tips. In fruit, the pod exceeding calyx, the beak directed upward, between dorso-lateral lobes.

Distribution and phenology

Southern Alberta, Saskatchewan and southwestern Manitoba, south throughout the short grass plains to western Texas, Durango, Arizona and southeastern Utah. Western representatives are always found at high altitudes, e.g. New Mexico, 6,000 ft. +, Arizona, 6,000 ft. +, Colorado, 4,500 ft. +. Adventive to the east in particularly xeric environments, e.g. the loess bluffs along the Missouri River at the Iowa-Nebraska border. Ubiquitous throughout its range except for the lower elevations to the west. It is found in sands, limestones and clays. Its aggressiveness is shown by its ability to colonize road cuts. Blooming time is from late May until early August, blooming first in the southern part of its range.

Nomenclature and observations

Except for the unverified virgatum to be discussed later, the epithet oligophyllum is the oldest applied to this taxon. It was not, however, elevated to the species level until two years after occidentalis was proposed, thereby losing priority. K. occidentalis Gray ex Heller is based on an unpublished Asa Gray name appearing on "Pringle's labels," P. candidus var. occidentalis. Fernald, in his later combination, Petalostemon occidentale, says:

..., Heller definitely stated that he was deriving the name from one used on herbarium-sheets but unpublished by Gray. It seems proper, then, to cite

Gray as the originator of the name.

His combination was published as, Petalostemum occidentale (Gray) Fernald. According to currently accepted rules Fernald's logic must be rejected since Gray's epithet was not validly published. The proper name should be P. occidentale (Gray ex Heller) Fernald.

Since neither Heller nor Fernald designated a type specimen, I have selected as a lectotype, a C. G. Pringle collection labeled, "Petalostemon candidus Michx., var. occidentalis, Gray. Mesas around the Mustang Mts. 26 June 1884," (US 24508).

Petalostemon gracile Gray is Fendler No. 135 from Plantae Fendlerianae (Gray 1849). One of this collection is at MO and it is clearly P. occidentale. I have not seen the type of P. gracile var. oligophyllum Torr. in Emory but according to Heller (1898):

The type, but unnamed, is in the herbarium of Columbia University. On a small slip of paper pasted upon the sheet is recorded in Torrey's hand "Emory, Sept. 28th, 1846. Valley of Del Norte."

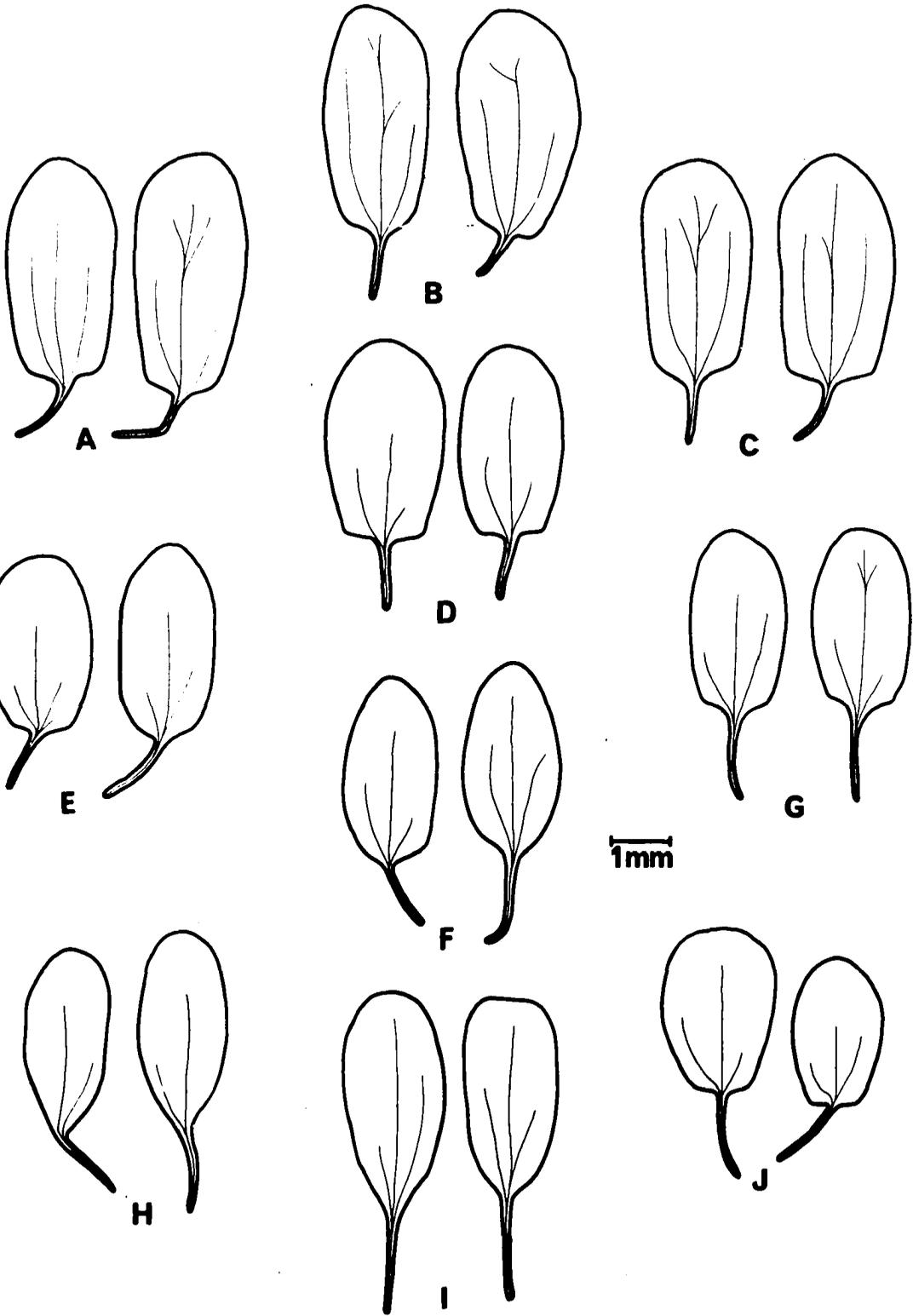
Heller continues by commenting that according to the journal this collection was made near Albuquerque, New Mexico. The Rydberg trinomial, K. candida occidentalis represents the first attempt to merge P. candidum, P. occidentale and P. multiflorum into a single species with three varieties. He cites no synonymy but lists 19 representative collections, all in NY. His publication of P. diffusa followed later the same

year and was said to be like K. candida occidentalis, "but prostrate, decumbent, or diffuse.... Petalostemon gracilis Gray in Pl. Fendl. may belong here. Deuel Co., Rydberg 58." I have examined four collections labeled Rydberg 58, only two of which have labels indicating the same location, although all are from Deuel Co. Three are referable to P. occidentale but the fourth is definitely P. candidum, the most western collection of that taxon. Rydberg does not include the epithet diffusa in Flora of North America (1919-1920).

P. truncatus Rydb. is based on Palmer 284, NY, collected at Tepehuanes, Durango. I have examined the type, an isotype at US, as well as three sheets annotated by Rydberg reassigning them to this taxon. The definitive characteristic of this species, according to Rydberg, is the presence of petals truncate at the base of the lamina. Had he examined petals from specimens collected throughout the range of P. occidentale he would have found that truncate petals are not an exclusive characteristic of plants from northern Mexico. With regard to petal shape I sampled specimens at random from this taxon (Fig. 37). The least truncate petals seen were from one of Rydberg's own collections (Rydberg 59, Deuel Co., Nebraska). The type location of P. truncatus is the southern-most spot on the distribution map.

P. sonorae, another Rydberg name proposed in the Flora of North America (1919-1920), is based on a Schott collection

Fig. 37. Variation in apical petals of Petalostemon occidentale throughout its range. A-C. Petals of specimens annotated in Rydberg's hand as P. truncatus. D-I. Petals of P. occidentale. A. Pringle 1216, Guerrero, Chihuahua (US). B. Pringle 1216, Guerrero, Chihuahua (NY). C. Nelson 7248, below Pacheco, Chihuahua. D. Warnock 323, Brewster Co., Texas. E. Livingston 496, El Paso Co., Colorado. F. Rydberg 1480, Hooker Co., Nebraska. G. Stevens 998, Greer Co., Oklahoma. H. Rydberg 59, Deuel Co., Nebraska. I. Wemple 3.5, rootstock in cultivation from Woodbury Co., Iowa. J. Wemple 165A, seedling in cultivation, the progeny of Wemple 3.5



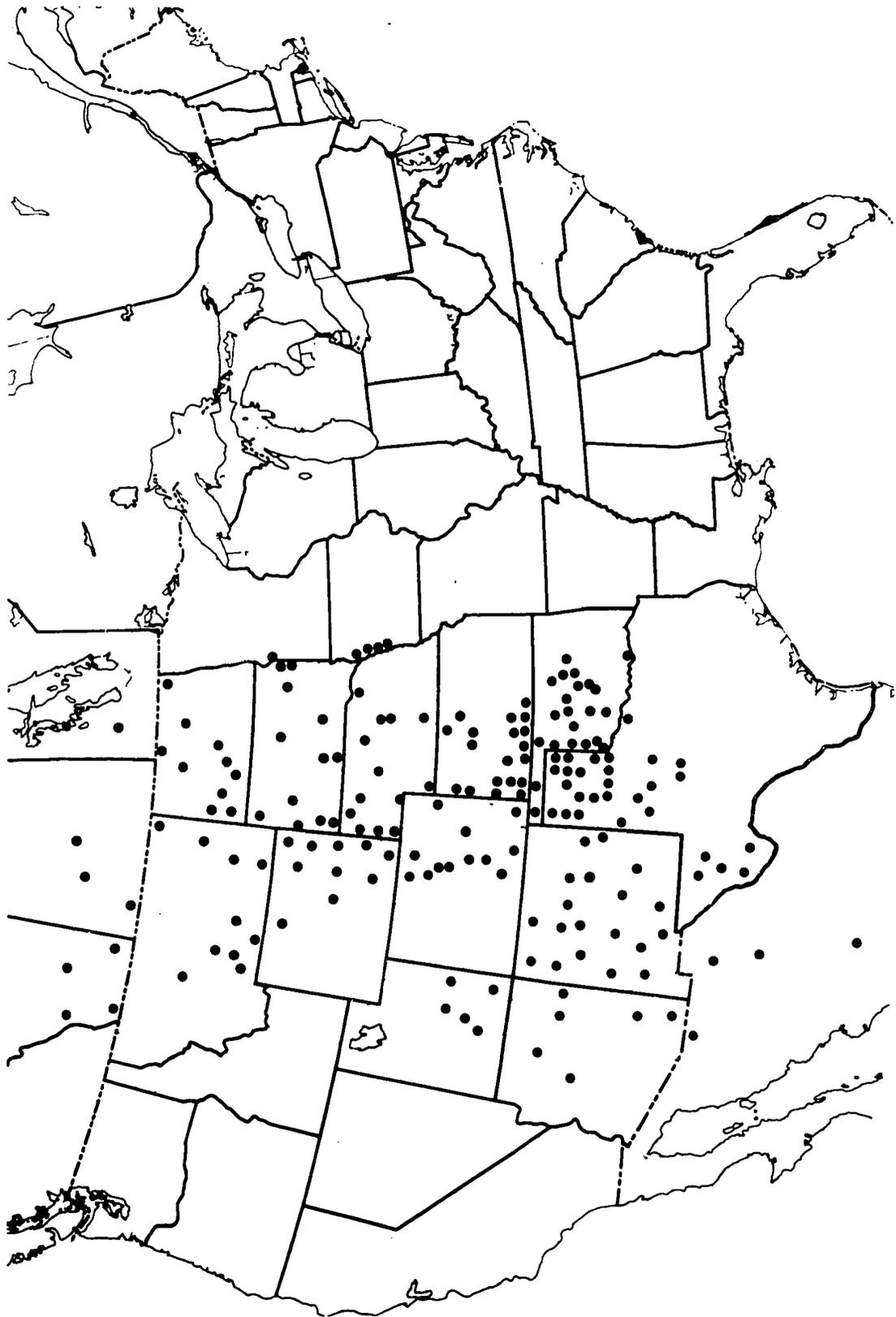
made during the Emory, Mexican Boundry Survey, No. 241. The location is shown on the distribution map as the most western Mexican collection. According to Rydberg, it is characterized by having: 1.) scattered leaves, 2.) long acuminate bracts exceeding the calyces in bud and in fruit, and 3.) compact spikes. I have examined the type and an isotype at NY and find them both to be well within the range of variability of P. occidentale. Both specimens have lost most of their upper leaves, the lower leaves, which are usually more scattered and larger, remain. The weak midrib, characteristic of P. occidentale, is clearly seen. The bracts barely exceed the calyx lobes in late bud and are usually lost prior to anthesis. There is evidence of some, although not excessive rachis expansion. T. H. Kearney recognized this taxon and five Arizona specimens are so labeled in US. On one (Peebles 5329) is the comment, "Related to P. oligophyllus and perhaps not sufficiently distinct. (THK)."

Petalostemum virgatum was included in the synonymy of P. candidum by Rydberg (1919-1920). Perhaps this placement was motivated by the title of Nees von Esenbeck's paper, "Botany of Missouri." From the description in the original publication, the specimen would seem to be P. occidentale. Particularly indicative of this is, "Calyx ... glaber aut pubescentia laxissima minutissimaque conspersus, compressus," I have been unable to locate the Nees herbarium and thus have not seen a type specimen for this name. If the description is

verified by a type, the epithet has clear priority over all other names and should be adopted.

Petalostemon occidentale can be distinguished from P. candidum on the basis of multiple characteristics as previously discussed. Gross, visual characters, easily seen in the field are: 1.) a more diffuse, spreading growth pattern, 2.) a lower leaflet number with smaller leaflets and 3.) a spike that elongates following anthesis. P. occidentale is not as homogeneous a species as P. candidum. Variation appears chiefly in leaflet size and shape. Throughout most of its range, the leaflets are small. If large leaflets are present, they are restricted to the lower portions of the stems; however, in Colorado and Montana there are specimens possessing only large leaflets. This condition mimics the leaflet size found in P. candidum and has been partly responsible for the identification of some Rocky Mountain material as P. candidum. In the same general area where the broad leaflet forms are found, the more typical plants have also been collected. Variation is also seen in calyx pubescence. Many of the western specimens lack pubescence entirely. This is particularly evident in those from the southwest. The ribs of the calyx nerves are also less prominent in the western specimens and some have rather pronounced bract "heels." In short, many of the western specimens seem more "candidum-like" than those found in the zone of overlap of the two species. Superficially one might hypothesize that the difference in

Fig. 38. Geographic distribution of Petalostemon occidentale



morphology of the eastern species in the sympatric region might be a reflection of a genetic barrier, operating to prevent introgression with P. candidum. Such a situation, called a "reverse cline" (Creed et al. 1959 and Harper et al. 1961) has been postulated in the study of animal species. That such a hypothesis is not warranted in this case, is the fact that the two species, even when geographically sympatric are not at all ecologically sympatric. P. occidentale is restricted to xeric habitats while P. candidum grows in the richer more mesic prairie habitats. A better explanation for the greater variability of P. occidentale as compared to P. candidum might be varying environments over the range in which the former species grows. As indicated above, all the western populations of P. occidentale are high altitude forms. Undoubtedly these habitats have acted as selectors for certain phenotypes different from those at the lower elevations. The variance exhibited by P. occidentale is probably a reflection of a basic plasticity within its genetic makeup.

10. PETALOSTEMON CANDIDUM Michx. (Figs. 39, 51A, 54B)

Petalostemum candidum Michx. Fl. Bor. Am. 2: 49, tab. 37, 1. (1803). Type material at P. (1)(2).

Dalea candida Michx. ex Willd. Sp. Pl. 3: 1337. (1802).

Psoralea candida (Michx.) Poir. In Lam. Encycl. Meth. 5: 694. (1804). Based on Dalea candida Willd.

Kuhnistera candida (Michx.) Kuntze. Rev. Gen. Pl. 1: 192. (1891). Based on Petalostemum candidum Michx.

Description

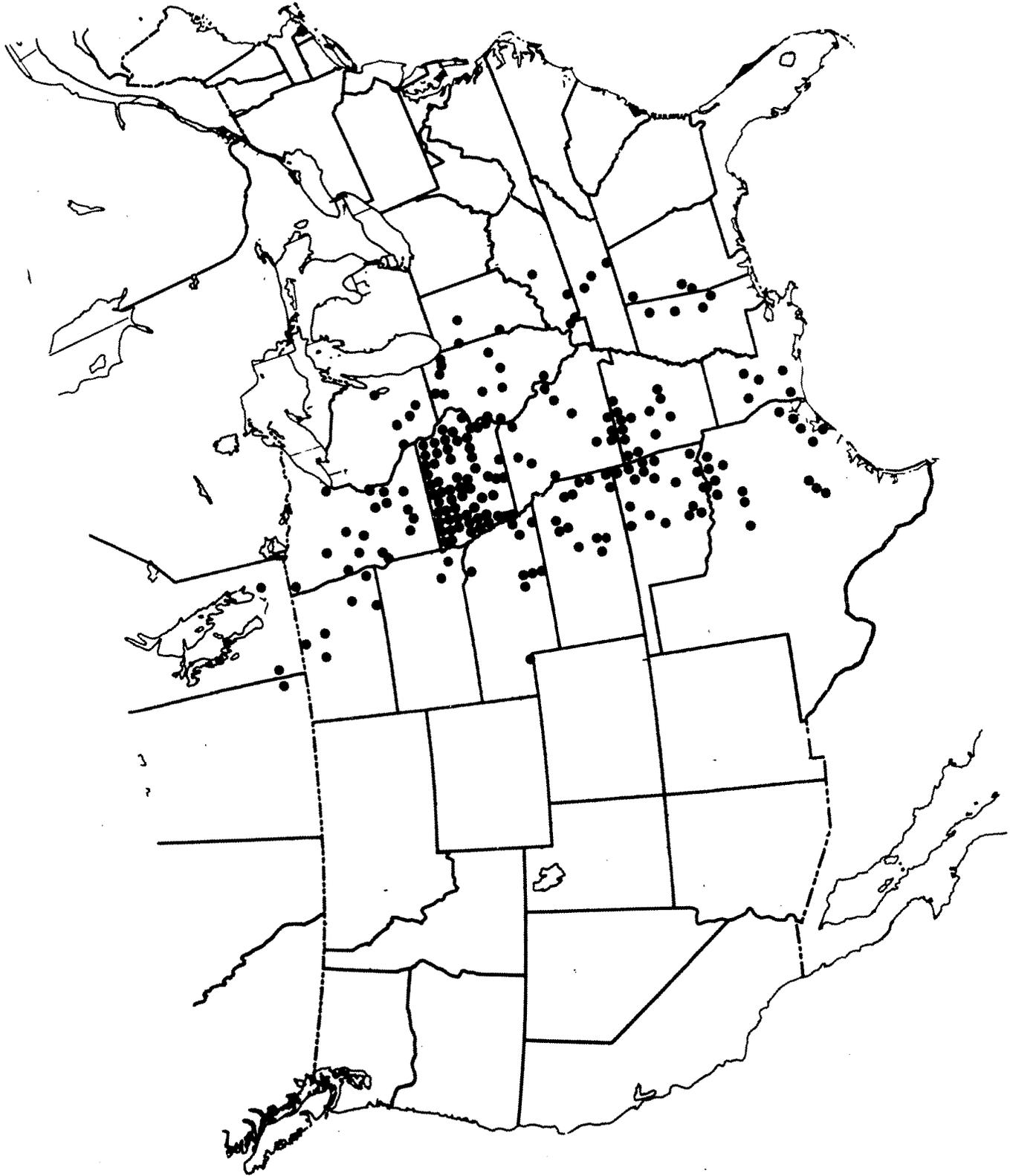
Stems few, arising from a woody caudex, 3--10 dm long, usually erect, moderately branching above; glabrous, striate, the protruding ribs drying white or pale green. Stipules white when fresh, drying straw-colored, persistent, subulate, 4--7 mm long. Leaves remote, glabrous, slightly fascicled, usually with not more than three small, inconspicuous, axillary leaves; rachis green, winged, often expanded just proximal to the petiolules forming a tubercle, always extended 1.0--3.5 mm beyond the terminal pair of leaflets; leaflets 5--9, elliptical to oblanceolate, 10--30 mm long, 2.5--7.0 mm wide, the lower surface dotted with small glands and possessing a prominent midrib when dry which usually terminates in a mucro. Peduncles 5--10 cm long, interrupted by prominent sterile bracts, 1--2 cm long, scattered below the spikes. Flowers in compact, non-expanding spikes, 1--8 cm long, 7--9 mm wide, sweetclover scented. Bracts precocious and persistent, far exceeding the calyx lobes in bud, slightly exceeding them at anthesis; body 2.0 mm long, ciliate margined, expanded and prominently glandular below the acumen; acumen subulate, often curved abaxially, abscission leaving a prominent "heel" on the rachis; paired, subulate, ciliate bracteoles, 1.5 mm long, flank the base of each flower. Calyx tube neither strongly ten-ribbed nor pubescent, usually drying with smoothly rounded longitudinal furrows; white, suffused with pink at the base when fresh, drying to a

pale straw color, 2.0--2.5 mm long, 1.7--2.0 mm in diameter; lobes green, ciliate on margins, lanceolate, the ventro-lateral lobes often directed upward overlapping dorsal-lateral lobes; ventral lobe, 1.4--1.6 mm long; a pair of prominent glands, drying yellow to bronze, immediately below each lobe between the calyx bundles. Corolla white; standard lamina strongly concave and lobed basally, 2.2--2.5 mm broad, 2.0 mm long, the claw 3.0--3.2 mm long; apical petals oblong-ob lanceolate, 2.2--3.3 mm long, 1.2--1.5 mm wide, slightly cuneate at base, the claw 1.8--2.2 mm long. Androecial tube not exerted beyond apex of calyx lobe, 3.5 mm long; filaments equalling or slightly exceeding the petal tips at anthesis; anthers pale yellow. Ovary globose, glabrous except for a tuft of cilia on dorsal surface, 0.7--1.2 mm long, 0.6--1.1 mm in diameter; teardrop-shaped glands prominent on proximal-lateral surfaces, smaller in size toward ventral side of ovary, drying dark colored; style exerted beyond petal tips soon after anthesis, 7.0 mm long. Pods exerted from calyx, the beak angled upward between dorso-lateral lobes, prominently glandular.

Distribution and phenology

A widespread species from southern Manitoba and Saskatchewan, eastern Dakotas, Minnesota and Wisconsin; south, to eastern Texas, Louisiana, Mississippi and Alabama. Occupying primarily prairie habitats, open woodlands and glades,

Fig. 39. Geographic distribution of Petalostemon candidum



occasionally adventive along roadsides. Replaced in the High Plains to the west by P. occidentale. P. candidum is ecologically sympatric with P. purpureum throughout most of its range; the two are frequently present on prairie remnants. Anthesis time is from mid May to late July, flowering proceeding south to north.

Nomenclature and observations

Many authors cite P. candidum (Willd.) Michx. on the basis of the earlier publication of Willdenow's Species Plantarum. As Isely (1962) points out (p. 120):

... since Michaux did not cite Willdenow (the contrary is in fact the case), his epithet would seem to be most properly considered a new name rather than a combination.

The correct citation should be P. candidum Michx.

It is probable that this species was introduced into Europe at the same time as P. purpureum. Both grow together in Illinois (the stated locale of the Michaux collections) and seeds of both were undoubtedly gathered and returned to Europe. In support of this hypothesis is a specimen from the Herbarier de Ventenat (G) which is labeled, "ex H. Cels." It was from a plant growing in the gardens of M. Cels that Ventenat described P. purpureum and it is likely that cultivation of P. candidum was attempted there also. A plausible explanation for Ventenat not including a report of both species in Description des plantes nouvelles et peu connues, cultivées

dans le jardin de S. M. Cels (1800), is that P. purpureum flowers more readily from seed than does P. candidum. Seedlings of the latter species rarely flower the first year while those of P. purpureum usually flower during their first growing season.

Isely & Welsh (1960) clarified the species status of P. candidum and P. occidentale. As they pointed out, the two are quite distinct when multiple characteristics are used for differentiation. My studies have corroborated their findings; however, I find no indication of any introgression in the sympatric zone of the two species. In fact, eastern specimens of P. occidentale (those sympatric with P. candidum) are more readily separated from P. candidum than are those collected farther west. Some of the western forms have many characteristics of P. candidum (e.g. broader leaflets and more glabrous calyces) but their habitats -- usually 5,000 ft. elevation and above -- are probably in part responsible for the apparent morphological convergence toward P. candidum. In the sympatric zone, the two species are not ecologically congruent. P. occidentale is always found in the more xeric habitats, whereas P. candidum is found in the mesic areas of rich prairie soil.

P. candidum and P. multiflorum are geographically sympatric over a great part of the range of the latter species. Habitat preference is almost identical and occasional interbreeding apparently takes place. The rare, putative hybrids

found in herbarium collections match those I have synthesized in the greenhouse.

Despite the few intermediates resulting from hybridization, P. candidum is morphologically consistent for such a wide ranging species. It can readily be recognized by its upright growth habit, relatively few leaves but large leaflets, long, non-expanding, columnar spike with precocious and persistent bracts. The main exceptions in growth pattern are found to the southeast where habitats of heavy clay soils and glade environments have evidently acted as selective forces to shape a more decumbent-prostrate stem and in general, a small plant. Despite the reduced size and growth habit of these plants, their floral characteristics match those in other areas of the range.

D. FOLIOSI

Distinguishing characteristics

Plants completely glabrous. Stems round below, becoming striate above. Leaves mostly solitary; leaflets 13--27. Spikes becoming lax at anthesis. Bracts lanceolate, scarcely expanded proximally, short ciliate on margins only, otherwise glabrous, far exceeding the calyx lobes in bud but early deciduous. Paired bracteoles present, flanking the base of the calyx. Calyx tube glabrous, ten-ribbed, gibbous dorsally and slit to almost one-half its length, slit margins ciliate as

are the lobe margins. Corolla pale lavender to rose; the standard broad, rounded-deltoid, its claw much thicker than the claws of the apical petals.

Distribution and ecology

Both species are rare and evidently restricted to specialized habitats in the Tennessee Basin and south central Texas. The northern species perhaps currently restricted to limestone glades; the southern species to "exposed rocks" and "limestone clefts" according to herbarium labels.

Observations

These two species, although widely separated geographically share many of the same characteristics, presumably indicating that they are closely related. Since both are highly restricted and rare, they possibly represent relic populations of formerly more widely spread taxa. They are both so distinct from the other species or groups of species of Petalostemon that it is unlikely that they arose as a result of relatively recent hybridization between more wide ranging species and persisted because of their ability to survive in specialized habitats. Possible distant relationship with P. prostratum, a rare endemic from New Mexico, is discussed under that species. Further collecting may possibly indicate that both are more widespread than currently known.

Key to the Species

1. Leaflets 20--29, elliptical; peduncles shorter than 3 cm; spikes compact; calyx tube not prominently gland-dotted; ovary covered with protuberant, spherical glands; Illinois and Tennessee.

11. P. foliosum p. 158

1. Leaflets 7--17, linear; peduncles 6--12 cm; spikes lax; calyx tube with numerous glands between ribs; ovary not glandular; Texas.

12. P. sabinale p. 161

11. PETALOSTEMON FOLIOSUM Gray (Figs. 35, 52D)

Petalostemon foliosus Gray. Proc. Amer. Acad. 7: 336. (1868). Type in GH. (1)(2).

Kuhnistera foliosa (Gray) Kuntze. Rev. Gen. Pl. 1: 192. (1891). Based on Petalostemon foliosus Gray.

Description

Stems several, 3--8 dm long, branching above, smooth, glabrous, round at the base but becoming striate immediately below the spike. Internodes 1.0--1.5 cm long. Stipules subulate, 3--5 mm long, persistent, becoming sinuous when dried. Leaves 3.5--4.5 cm long, initially solitary at nodes ultimately becoming fascicled on older stems; leaflets 20--29, evenly spaced along rachis, not always paired; petiolules 0.5 mm long with a prominent gland on lower surface of the rachis

at the point of insertion; blades 6--10 mm long, 2.5--3.5 mm wide, elliptical to elliptic-obovate, mucronate, finely gland-dotted; midrib very prominent on the ventral surface. Peduncles short, 1.5--2.5 cm, bearing scattered sterile bracts, 5--6 mm long. Spikes clustered, moderately compressed, cylindrical, 8--10 mm broad, 25--50 mm long. Bracts subulate, expanded in the center, about 5 mm long, far exceeding the calyx lobes in bud, becoming chartaceous and falling soon after anthesis. Subulate bracteoles flank the calyx, 0.5--1.0 mm in length. Calyx tube white, thin walled, 3.5--3.8 mm long, gibbous distally, narrowing proximally, slit dorsally to almost one-half its length, slightly oblique, laterally ribbed; rachis attachment point below the longitudinal axis of the tube; lobes deltoid, green, appressed pubescent on inner surface and margins, the ventral lobe 2.0 mm long. Corolla pale purple, the petals widely reflexed; standard ovate-emarginate, 3 mm wide, 2.5 mm long; claw 4 mm long, 0.3 mm thick (over twice as thick as claws of apical petals); apical petals strap shaped, 2.7 mm long, 0.8 mm wide, slightly truncate anteriorly, cuneate at base, the claw 0.8 mm long. Staminal tube 3.6 mm long, shorter than calyx lobes; filaments 4.0 mm long, the anthers bright red-pink prior to anthesis; pollen orange. Ovary spheroidal, 1.4 mm long, 0.9 mm in diameter, glabrous, covered with protuberant, spherical glands; style glabrous, 5.5 mm long. Pod gland-dotted, exserted slightly from calyx, the anterior portion directed upward between the dorso-lateral

lobes.

Distribution and phenology

Known originally from northern Illinois and the Tennessee Basin, perhaps now restricted only to the latter area. The only collections in the last fifty years that I have seen have been from a limestone glade across from Stone River Park, two miles northwest of Murfreesboro, Rutherford Co., Tennessee, (DeSelma (Year) 1879; Sharp & Shanks 25455; and, Isely & Wemple 9420) and "U. T. Farm," Knox Co., Tennessee, (Lanher 20). Blooming time is from July to mid September.

Observations

The type sheet in the Gray Herbarium bears two collections, those of Truesdale (year) 1867, Kane Co., Illinois and Hatch (year) 1854, Nashville, Tennessee. Both are cited by Gray. A similar mixed sheet is at MO and a specimen of the Truesdale collection is at NY. There have been no collections from the intervening areas and as previously stated, a total of only four collections have been made in this century. The habitat of the "cedar glades" of the Tennessee Basin has been discussed under P. gattingeri, a species also endemic to these areas. My collection of this taxon (Isely & Wemple 9420) was late in the season and only a few axillary spikes remained in bloom. Seeds were collected and the plants grown and flowered in the Iowa State University greenhouse. They grew well in

our prairie loam potting soil and flowered readily. Observations of living plants and fresh flowers facilitated preparation of the above description. As with all other species of Petalostemon cultivated under greenhouse conditions, there appear to be no artifacts induced. Pressed specimens from the greenhouse appeared exactly like those collected in the field.

This taxon is quite distinct from any other. Its possession of many leaflets, long, precocious, subulate bracts, bracteoles and glabrous calyx seem to relate it to P. sabinale (Rydberg, 1919-1920, places them in the same section), but leaflet shape, peduncle length, calyx shape, texture, and glandlessness as well as a glandular ovary, set P. foliosum apart.

12. PETALOSTEMON SABINALE Wats. (Fig. 35)

Petalostemon sabinalis Wats. Proc. Am. Acad. 21: 448-449. (1886). Type in GH. (1)(2).

Kuhnistera sabinalis (Wats.) Heller. Bull. Torr. Bot. Club 23: 124. (1896). Based on Petalostemon sabinalis Wats.

Petalostemon luteolus Wats. ex Heller. Bull. Torr. Bot. Club 23: 122. (1896).

Description

Stems many, unbranched, erect, 2--4 dm long, glabrous, slightly glandular, round at the base becoming slightly striate above. Stipules fugacious, 2--4 mm long, subulate, often

curved. Lower leaves solitary, the upper ones often with suppressed axillary branch systems; rachis 2.0--2.5 cm long, glabrous, glandular, extended beyond terminal pair of leaflets 0.8--1.5 mm; leaflets (7) 13--15 (17), linear, narrowed at the base, 9--13 long, 1.5--2.0 mm wide, pale green above, darker green and gland-dotted below. Peduncle glabrous, 6--9 (12) cm long, rarely bearing sterile bracts near the apex. Inflorescence an expanding spike, up to 5 cm long; rachis glabrous to glabrate. Bracts precocious, far exceeding the calyx lobes in bud, deciduous before anthesis, lanceolate, only slightly broadened at the base, short-ciliate on margins; paired, ciliate bracteoles 0.5--1.0 mm in length, flank the calyces. Calyx expanded-tubular, slightly ten-ribbed, 2.2--2.9 mm long, slit dorsally almost half its length, glabrous except for margins of dorsal slit which are short-ciliate; tube glandular at base of lobes with numerous, yellow, pellucid, protuberant glands 0.2--0.3 mm in length, 0.1 mm wide; lobes ciliate, the ventral lobe 0.8 mm long. Corolla rose to pale lavender (?); the standard rounded-deltoid, 3.0 mm long, 3.5 mm broad, slightly emarginate at apex, the claw 3.5--3.9 mm long, thicker than the claws of the apical petals; apical petals 3.5 mm long, 1.0 mm wide, the claws 1.0 mm long. Androecial tube exerted beyond tips of the lobes, 3.5 mm long; the free filaments 5.3 mm long. Ovary 1.4 mm long, 1.0 mm in diameter, only slightly short-ciliate on dorsal, distal surface; the style 8 mm long. Pod not exceeding calyx lobes but bent

upward between dorsal lobes, short ciliate on apical margins.

Distribution and phenology

Known from only five collections in Texas; Bandera, Brewster, Uvalde and Val Verde counties. Apparently blooming in mid May.

Nomenclature and observations

The epithet luteolus was a tentative name placed in parentheses on the label of the type specimen of P. sabinalis by Sereno Watson. Watson eventually rejected the name and published the species as P. sabinalis. Heller (1896) restored the epithet, in a sense, by commenting:

Petalostemon luteolus S. Wats., is P. sabinalis S.

Wats. Although the name luteolus appears in Patterson's Check-List, it has no foundation, being a label name given to a specimen of P. sabinalis.

The affinities of P. sabinale are decidedly with P. foliosum as first suggested by Rydberg (1919-1920). Turner (1949, p. 165) indicates that it is, "Closely related to P. stanfieldii [P. tenue] and apparently intergrading with that species." I find no evidence to support this view. It is true that the range of the two species is contiguous and that the leaflet number is similar, but all other characteristics are decidedly different -- the two are quite remote morphologically.

It is possible that this species is more common than the paucity of collections indicate and could be "rediscovered." The type location, "entrance to Sabinal Canyon," is not readily accessible, but a 1944 collection (Cory 44424, Val Verde Co., Texas) 12 3/4 miles south of Loma Alta, Texas is apparently along a highway. I collected for a day in this area during mid June, 1962 but did not find the species. My efforts were probably too late in the season and perhaps an earlier visit would bring it to light.

E. PHLEOIDES

Distinguishing characteristics

Stems striate with protuberant, globose glands; leaflets 11--48, glabrous to pubescent, sessile or nearly so; spikes 1.3--6.7 cm long, often becoming sinuous, 5--9 mm wide; bracts linear, exceeding calyx lobes, often deciduous; paired filiform bracteoles present, flanking the calyces; calyx oblique, deeply slit and dorsally gibbous, the lobes very short; corolla white, the standard broad, the apical petals strap-shaped.

Distribution and ecology

Dry sandy areas of south and east Texas and adjacent Oklahoma.

Observations

This section is easily recognized by its white flowers, dorsally gibbous calyx, numerous leaflets and spherical, protuberant glands, to 0.3 mm in diameter. The glands, when ruptured, release a pungent, watery liquid that has a sharp, distinctive odor. P. microphyllum has been in greenhouse cultivation for over two years. It thrives and flowers freely when grown in Iowa prairie soil. All attempts at cross-pollination with other species of other sections have been unsuccessful; indicative, as is the morphology, of the distinctiveness of these species within the genus.

The treatment of this section is in large part based upon unpublished investigations of Wesley S. Jackson (1964). Prior to Jackson's study, *Phleoides* was conventionally considered to contain three species (Rydberg 1919-1920, Turner 1959), but their distinguishing characters were far from clear. On the basis of analyses of mass collections as well as field and herbarium studies, Jackson demonstrated the existence of two reasonably distinct taxa. Their diagnostic characteristics are presented in the following key.

Key to the Species

Calyx glabrous; leaves (0.7) 1.3--2.3 (3.8) cm wide, leaflets 11--26, usually under 21; peduncles usually possessing sterile bracts.

13. P. phleoides p. 166

Calyx pubescent; leaves (0.5) 0.6--1.5 (2.0) cm wide, leaflets 15--48, usually over 25; peduncles usually lacking sterile bracts.

14. P. microphyllum p. 168

13. PETALOSTEMON PHLEOIDES T. & G. (Fig. 40)

Petalostemon phleoides T. & G. Fl. N. Am. 1: 310. (1838). Type in NY. (1)(2).

Petalostemon aphleoides Young. Fl. Tex. 221. (1873). (2).

Kuhnistera phleoides (T. & G.) Kuntze. Rev. Gen. Pl. 1: 192. (1891). Based on Petalostemon phleoides T. & G.

Petalostemon glandulosus Coult. & Fish. Bot. Gaz. 18: 299. (1893). Type in US. (1)(2).

Dalea phleoides (T. & G.) Shinnars. Field and Lab. 17: 83. (1949). Based on Petalostemon phleoides T. & G.

Dalea glandulosa (Coult. & Fish.) Shinnars. Field and Lab. 17: 83. (1949). Based on Petalostemon glandulosus Coult. & Fish.

Description

Multiple stems ascending from a rusty to deep red taproot. Stems 2--7 dm long, glabrous to slightly pubescent, striate, and glandular. Stipules 2.5--3.5 mm long, pubescent, subulate from a broad base. Leaves 2.1--6.7 cm long, 0.5--3.8 cm wide, glabrous to pubescent; leaflets 11-26, elliptical to obovate, 1.5--2.5 mm long, 0.4--1.0 mm wide. Peduncles 0.1--26.3 cm long, usually with scattered sterile bracts near the apex. Spikes dense, cylindrical, becoming lax and sinuous in fruit,

13--58 mm long, 5--9 mm wide. Bracts glabrate in the southern portion of the range, becoming more pubescent northward, exceeding the calyx lobes in bud, deciduous prior to anthesis. Bracteoles present, flanking the calyces, 0.6--1.0 mm in length. Calyx glabrous; the tube oblique, 2.2--2.6 mm long, slit more than one-half its length dorsally, glandular between the nerves; lobes 0.6--0.9 mm long, ciliolate on the margins. Corolla white; the standard blade cordate, 2.5--3.5 mm long, 2.5--3.5 mm wide, the claw 3--4 mm long; apical petals linear, 3.0--3.5 mm long, 0.6 mm broad, the claws 2.0 mm long. The staminal tube about 2.7 mm long, the free filaments 2.5--3.5 mm long; anthers orange. Ovary 1.0 mm long, glabrous; the style 5 mm in length, proximally pubescent on the upper surface for one-third its length. Pod obliquely obovoid.

Distribution and phenology

Eastern and southern Texas. Primarily confined to deep sands of pine and oak woodlands. Flowering from mid May to mid July, reaching a maximum the third week of June.

Nomenclature and observations

Although Rydberg (1919-1920) and Turner (1959) upheld separation of P. phleoides and P. glandulosum, merger of the two species was first proposed by Heller in 1896 (p. 123).

Under Kuhnistera phleoides, he writes:

A comparison of the type of phleoides and a duplicate type of glandulosus, both of which are in the Columbia University Herbarium, clearly shows them to be identical. The oblique calyx is a marked character in this species.

Heller also indicated the general lack of pubescence of K. phleoides in his earlier remarks regarding K. microphylla. Jackson's detailed study of these species corroborates Heller's intuitive approach.

14. PETALOSTEMON MICROPHYLLUM (T. & G.) Heller (Fig. 40, 52B, 54C)

Petalostemon microphyllum (T. & G.) Heller. Bull. Torr. Bot. Club. 26: 593. (1899). Based on Petalostemon phleoides var. microphyllum T. & G.

Petalostemon phleoides var. microphyllum T. & G. Fl. N. Am. 1: 310. (1838). Isotype in US. (1)(2).

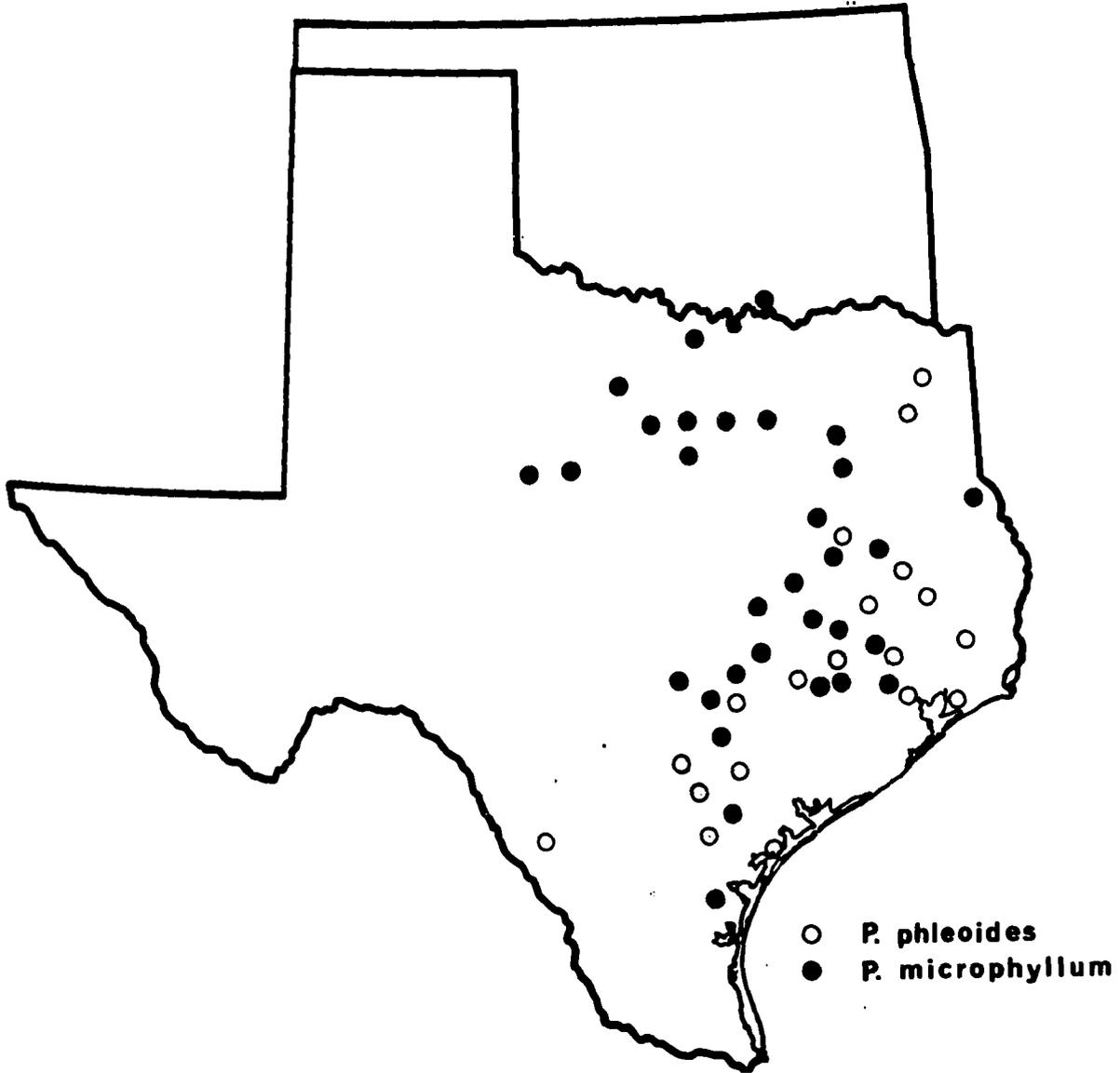
Kuhnistera microphylla (T. & G.) Heller. Bull. Torr. Bot. Club. 23: 122. (1896). Based on Petalostemon phleoides var. microphyllum T. & G.

Dalea drummondiana Shinnars. Field and Lab. 17: 83. (1949). Based on Petalostemon phleoides var. microphyllum T. & G.

Description

Stems arising from a deep, red taproot, 2--7 dm long, glabrous to pubescent, striate, with protruding, globose glands. Stipules 3--5 mm long, curved. Leaves 1.4--6.0 cm long, 0.5--1.8 cm wide, glabrous to pubescent (densely so on

Fig. 40. Geographical distribution of Petalostemon
phleoides and P. microphyllum



young leaves); leaflets 15--48, elliptical to obovate, sessile or nearly so, 4--7 mm long, 1.5--2.0 mm wide. Peduncles 0.1--22.5 cm long, usually without sterile bracts near the apex. Spikes 5--103 mm long, 5--8 mm wide. Bracts exceeding the calyx in bud, often deciduous, linear to linear-lanceolate, 4--5 mm long, 0.3 mm wide with subulate to subulate-filiform tips, glabrous to pubescent. Paired bracteoles present flanking the calyx, 0.6--0.8 mm long, filiform. Calyx oblique; the tube 3 mm long, slit dorsally to more than one-half of its length, dorsally gibbous; the lobes short, the ventral lobe less than 1.3 mm long, ciliolate on the margins. Corolla white; the standard blade cordate, 2.5--3.0 mm long, 2.5--3.5 mm wide, the claw 3--4 mm long; apical petal blades linear to linear-oblongate, 2.5--3.5 mm long, about 0.7 mm wide, the claw 1.5--2.5 mm long. Androecial tube exerted slightly beyond the tips of the calyx lobes. Ovary 1.4 mm long, 0.8 mm in diameter, ciliate on the proximal two-thirds. Pod obliquely obovoid.

Distribution and phenology

Northern and eastern Texas in the deep, dry sands of the Cross Timbers and Prairies, Blackland Prairies, and South Texas Plains vegetational areas (Gould 1962). North to Montague county, south to Nueces county and extending west to Taylor county, Texas. Also from Marshall county, Oklahoma. Flowering from late May to mid July, reaching a maximum during

the second week of June.

Observations

This is a variable species and Turner (1959) has suggested that two varieties are possibly represented. His conjecture was based on the more glabrous condition of the northern populations. Jackson confirms Turner's observations but states:

However, no reasonable cline can be observed. Further, no other morphological features seem to exhibit a north-south bifurcation. Thus at this time Petalostemon microphyllum is considered as one entity though a highly variable one.

(Jackson 1964). He concludes his discussion with this paragraph:

From both field and herbarium experience, both species of the section are highly variable. Each is probably represented by individual colonies or populations with not much interbreeding from one colony to the next, thus each colony is highly individualistic.

F. VILLOSI

Distinguishing characteristics

Stems arising from a long, red, seldom branched taproot; stems and leaves villous, leaflets (9) 11--19 (21), less than 1.5 cm long; spikes lax, usually 5--12 cm long and less than 1 cm broad; flowers pale lavender, rose to almost white.

Distribution and ecology

Texas, northward to southern Saskatchewan, throughout the Plains area on sandy soil, sandhills and blowouts.

Key to the Species

1. Stems reddish, striate, spreading pubescent; leaves thinly pilose, leaflets 10--15 mm long; not possessing sterile bracts below spikes; standard broad, cordate; east Texas and western Louisiana.

15. P. griseum p. 174

1. Stems pale, striations usually concealed by villous investiture; leaves densely villous, leaflets 8--11 mm long; sterile bracts straggling down peduncle below spike; standard oblong, truncate or rounded at the base; central or north Texas and northward.

16. P. villosum p. 179

15. PETALOSTEMON GRISEUM T. & G. (Fig. 41)

Petalostemon griseum T. & G. Fl. N. Am. 1: 310. (1838).
Type in NY. (1)(2).

Kuhnistera grisea (T. & G.) Kuntze. Rev. Gen. Pl. 1:
192. (1891). Based on Petalostemon griseum T. & G.

Dalea grisea (T. & G.) Shinnars. Field and Lab. 17: 84.
(1949). Based on Petalostemon griseum T. & G.

Description

Plants arising from a long, relatively unbranched, red taproot, which is up to 4 dm in length. Stems erect, reddish, finely striate, spreading ciliate but not villous; usually branched in the upper half, (4) 6--7 (9) dm tall, 4--5 mm thick at the base. Stipules subulate, dark, 5--6 mm long. Leaves 2--4 cm long; rachis extended beyond the terminal pair of leaflets 1--2 mm; leaflets (9) 11--13 (15), oblong-elliptical, mucronate, slightly pubescent on both surfaces, but predominantly so on the lower surface, 10--15 mm long, 2.7--4.2 mm broad, not always perfectly paired on the rachis. Spike sessile; the peduncle a maximum of 3 cm in length, often with straggling flowers near the apex; spike lax, flowering at 4 cm in length and through further floral differentiation reaching a maximum length of 14 cm, becoming sinuous and nodding; (6) 7--9 mm in diameter. Bracts lanceolate, only slightly expanded proximally, exceeding the calyx in bud, usually falling prior to anthesis leaving a decided "heel" on the rachis. Calyx spreading-ciliate; the tube ten-ribbed,

clearly visible, pale, slit dorsally to almost one half its length, 2.0--2.2 mm long, 1.7--2.0 mm in diameter; ventral lobe 1.0--1.2 mm long, each lobe tipped with a minute gland. Corolla pale lavender; standard blade cordate, entire at the apex, 2.1--2.6 mm long, 2.5--2.8 mm broad, arching over the other floral parts, the claw 2.3 mm long; apical petals oblong to slightly oblanceolate, 2.3--2.6 mm long, 1.0--1.2 mm wide, the claws 0.5 mm long; medial petals inserted lower than the lateral petals on the staminal tube. Staminal tube 3 mm long, equalling the length of the free filaments; anthers pale yellow. Ovary villous except at the extreme proximal end, 1.0--1.3 mm long, 0.8 mm in diameter; style 4 mm long, ciliate only on the proximal one-fourth. Pod not exerted beyond the calyx lobes, villous, thick walled.

Distribution and phenology

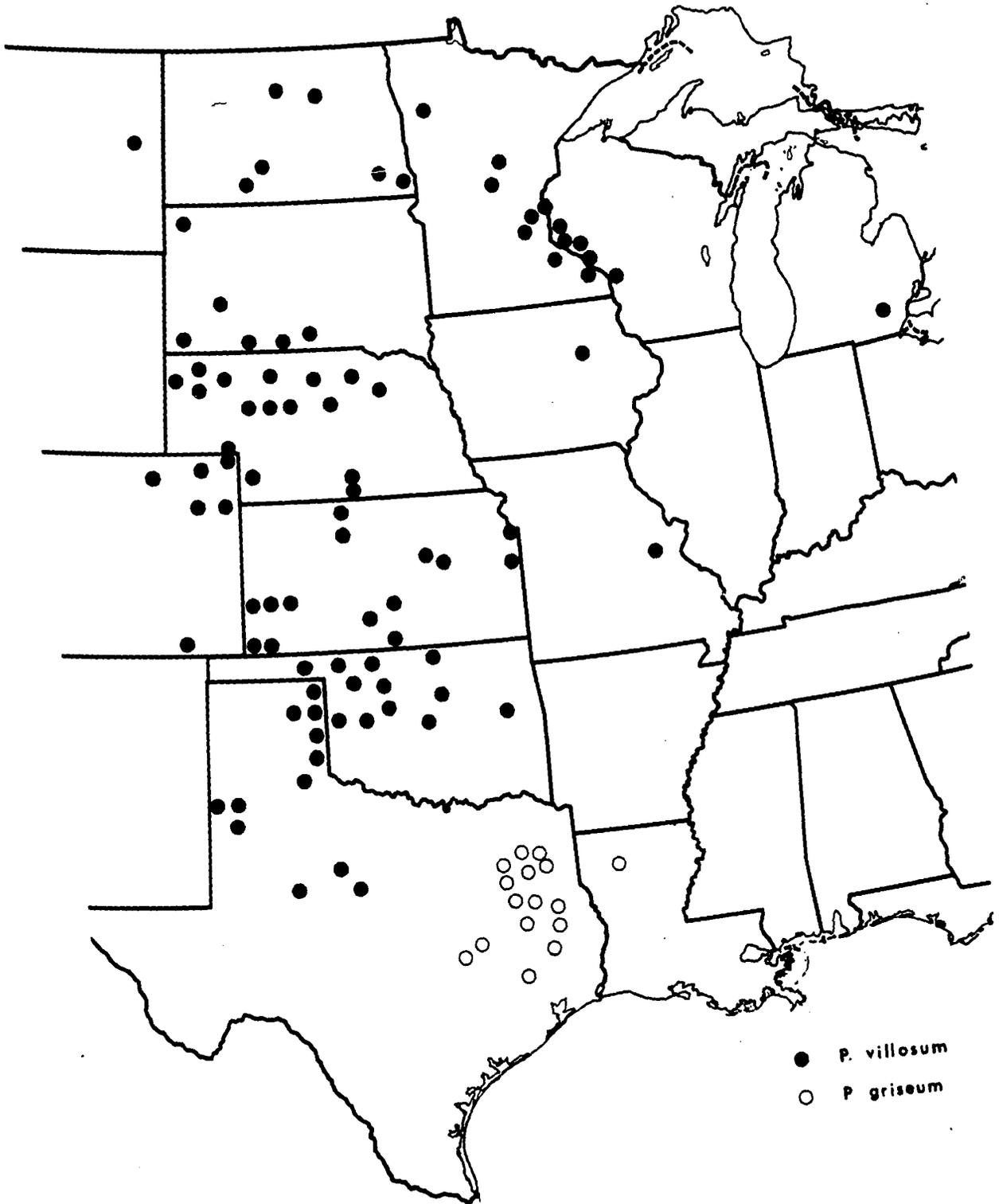
Limited to east Texas and western Louisiana. Restricted to sandy soils. Flowering from late May to late June, reaching a maximum approximately the second week of June.

Nomenclature and observations

Torrey and Gray cite two collections, "Pine woods near the Sabine River, Dr. Leavenworth! Texas, Drummond!". Both are mounted on one sheet at NY. The Leavenworth specimen (two stems) is taken as the type.

Petalostemon griseum is very closely related to P.

Fig. 41. Geographical distribution of Petalostemon
villosum and P. griseum



villosum; indeed, all of the identifying characteristics of the former are found sporadically throughout the range of P. villosum. The possession of a specific array of characteristics in conjunction with allopatric distribution, however, is the basis for considering P. griseum a distinct species. Distinguishing between the two species in the field is relatively simple: P. griseum has fewer stems, grows taller, branches more profusely in the upper half and all spikes become long and nodding in fruit. Most of these characteristics cannot be readily transferred to herbarium sheets; thus, the correlation of several "minor" characteristics must be used for identification. In general, P. griseum 1) is less pubescent, 2) has reddish stems, 3) possesses larger leaflets, 4) often has "straggling" flowers below the main body of the spike, 5) has extremely long spikes and 6) has a broad, cordate standard. In conjunction with the earlier flowering time and the geographic restriction to west Texas and eastern Louisiana, P. griseum can be recognized readily from herbarium specimens.

These species cannot be separated, either in the field or in the herbarium, on the basis of spreading or ascending leaves, calyx length or spike width as proposed by previous authors.

16. PETALOSTEMON VILLOSUM Nutt. (Figs. 41, 52A, 54A)

Petalostemon villosum Nutt. Gen. N. Am. Pl. 85. (1818).
Type in PH. (1)(2).

Dalea villosa (Nutt.) Spreng. Syst. Veg. 3: 326. (1826).
Based on Petalostemon villosum Nutt.

Kuhnistera villosa (Nutt.) Kuntze. Rev. Gen. Pl. 1: 192.
(1891). Based on Petalostemon villosum Nutt.

Description

Taproot seldom branched, red, 2--4 dm long, usually equalling the stems in length. Stems many, radiating or ascending, often branching near the apex, 2.5--3.5 (5) dm long, 3.5--5.0 mm thick at the base, densely villous, the pubescence often obscuring the stem surface. Stipules subulate, spreading-villous, 5--7 (9) mm long. Leaves fascicled, often crowded; rachis 1.5--3.0 (4.0) cm long, villous, bearing prominent, red "stipel-glands", 0.2 mm in diameter, below the petiolule insertions; the midrib always extended 0.5--1.5 mm beyond the terminal pair of leaflets; leaflets 13--19 (21), gland-dotted below, long, appressed pubescence on both surfaces, 8.5--11.0 (13) mm long, 2--3 (3.5) mm broad. Spikes sessile and lax, the rachis expanding following anthesis, often becoming sinuous in fruit, 4.5--11.0 (15) mm long, 8--10 (11) mm in diameter; sterile bracts often spread along the short peduncle below the spike. Bracts exceeding the calyx lobes in bud, villous throughout their length, 4--6 mm long, 1.2--1.4 mm broad, the acumen 2--4 mm long, usually deciduous

immediately following anthesis. Calyx ten-ribbed, the surface often obscured by dense, spreading pubescence; the tube 2.0--2.4 mm long, split dorsally to one-third its length; the ventral lobe 0.9--1.4 mm long. Corolla lavender-purple to almost white; the standard blade never becoming erect and open but usually covering the other floral parts, 2.7 mm long, 2.0--2.5 mm broad, oblong to oval, sometimes truncate at the base, rarely cordate, often emarginate at the apex; the claw 2.3--2.5 mm long; apical petals obovate, 2.6--2.8 mm long, 1.0--1.2 mm wide, the claw short, 0.5 mm; medial petals inserted on the staminal tube lower than the lateral pair. Staminal tube 2.2 mm long, the free filaments 3.7 mm long; anthers yellow to yellow-orange, exceeding the petal apices at anthesis. Ovary spreading-ciliate on the distal two-thirds, 1.0--1.1 mm long, 0.8 mm in diameter, the style 4.5 mm long, ciliate dorsally from the proximal end to barely one-third its length. Pod spreading-villous, exserted beyond the calyx lobes at maturity, the distal end bending upward between the dorsal calyx lobes.

Distribution and phenology

Restricted to sandy soils, sand hills and blow-outs; ranging from southern Saskatchewan to northern Texas and from eastern Colorado to eastern Missouri. Flowering beginning in late June in the southern part of its range, mid July in its northern part; most flowering terminated by mid August.

Observations

This is a wide ranging yet homogeneous species with a specific habitat preference for deep sand. Despite its ecological requirements in the field, it appears to grow and flower well in the greenhouse even though potted in Iowa prairie loam. Color variations are seen in the field as well as under greenhouse conditions, the petal colors ranging from almost white to light purple. The colors occur randomly distributed in most populations I have seen. Variations in degree of pubescence as well as leaflet number also exist but appear to show no specific regional trends, indicative possibly of a genetic plasticity expressed as varying phenotypes. P. villosum is replaced in east Texas and western Louisiana by P. griseum, a species with which it shares many characteristics.

G. COMPACTI

Distinguishing characteristics

Root in most species a relatively unbranched taproot. Leaves solitary, seldom fascicled, the leaflets broad-elliptical to almost ovate. Spikes 1.0--2.0 cm in diameter with sterile bracts often found at the spike base. Fertile bracts concave, lanceolate to obovate with a strong midrib and scarious margins toward the proximal end, densely villous-sericeous, always exceeding the calyx lobes in bud and

equalling or exceeding them in fruit. Calyx usually thin-walled and ciliate, the lobes villous-sericeous. Petals often inserted slightly below the apex of the androecial tube. Pod usually not exerted beyond the apex of the calyx lobes at maturity.

Distribution and ecology

Generally, plants of the west -- south Texas through the Short Grass Plains to western Nebraska and Wyoming and west to the Continental Divide in the Columbia Plateau, southward to Nevada, Utah and northern Arizona. Most species are found in sandy soils.

Observations

This is perhaps an unnatural grouping, yet there appear to be pairs or trios of species which form links, one with another, which eventually tie all of the species together. Petalostemon obovatum, a sand dwelling endemic of south Texas seems quite different from most species of Petalostemon but has several characteristics in common with the rare Short Grass Prairie species, P. compactum. The latter species shares common characteristics with P. ornatum of the Columbia Plateau in the Pacific Northwest. P. flavescens of southeastern Utah seems related to both P. searlsiae of Nevada, Utah and Arizona and P. ornatum, thus completing the circle of species.

P. ornatum, P. compactum and P. flavescens all possess

petals that are inserted slightly below the apex of the staminal tube. This characteristic is also shown by P. tenuifolium of the Purpurei group. This variation from true apical petal insertion is very slight -- observable only with 30x magnification or higher. The petals are much closer to the apex than in any species of Dalea I have examined.

Key to the Species

1. Calyx slit dorsally to one-half its length; calyx tube relatively thick, neither transparent nor long-ciliate, plants of the Great Basin.
2. Corolla purple; calyx oblique, ventral calyx lobe 1.0--1.4 mm long; rachis elongating, spreading the calyces in fruit, spike over 4 cm long; plants of Nevada, adjacent counties in California, N. W. Arizona and E. Utah.

17. P. searlsiae p. 184

2. Corolla yellow or yellowish-white; calyx not oblique, ventral calyx lobe 1.5--2.5 mm long, spike remaining compact in fruit, less than 4 cm long; plants of S. E. Utah and adjacent N. Arizona.

18. P. flavescens p. 191

1. Calyx not slit dorsally to one-half its length, calyx tube thin-walled, transparent, long-ciliate; plants of southern Texas, the High Plains or the Pacific Northwest.

3. Corolla purple; stipules less than 3 mm long, plants of central Nevada and the Pacific Northwest.

19. P. ornatum p. 194

3. Corolla yellow to yellowish-white; stipules longer than 3 mm, plants of the High Plains and southern Texas.

4. Stems and leaves glabrous; leaflets elliptical-acute; peduncles 5--15 cm long; inflorescence less than 1.2 cm thick; plants of the High Plains.

20. P. compactum p. 199

4. Stems and leaves pilose; leaflets broad-obovate; peduncles 1 cm long or shorter; inflorescence thicker than 1.2 cm. Plants of S. Texas.

21. P. obovatum p. 202

17. PETALOSTEMON SEARLSIAE Gray (Fig. 42)

Petalostemon searlsiae Gray. Proc. Am. Acad. 8: 380. (1872). Type in GH. (1)(2).

Kuhnistera searlsiae (Gray) Kuntze. Rev. Gen. Pl. 1: 192. (1891). Based on Petalostemon searlsiae Gray.

Petalostemon rothrockii Rydb. F. N. Am. 24: 134-135. (1919-1920). Type in NY. (1)(2).

Description

Stems numerous, glabrous, often decumbent at the base, 3--5 dm long, glaucous-green, conspicuously gland-dotted with red-brown protuberant glands, these more numerous and conspicuous toward the stem apex. Stipules lance-subulate, deciduous, 1--2 (3) mm long. Leaves glabrous, usually solitary at nodes; rachis 1.5--2.5 (3.5) cm long with prominent "stipei-glands" below the petiolule insertions, extension beyond terminal pair of leaflets seldom over 1 mm; leaflets 5--7 (9), 9--16 mm long, 2--6 (8) mm broad, oblong to slightly obovate, often emarginate with a gland at the apex of the midrib, glandular below, smooth above; margins only slightly involute, but leaflets often folding when pressed, the midrib bending abaxially, especially so toward the leaflet apex. Peduncles long, 10--20 cm, glabrous, often with a few sterile bracts straggling below the main body of the spike. Inflorescence an expanding spike, compact in bud, becoming lax in fruit; spike 3--4 cm at anthesis, expanding to 6.5--9.0 (13) cm in length, 8--11 (12) mm wide; rachis glabrous to moderately pubescent, becoming visible in fruit. Bracts deciduous as spike expands, rhombic-lanceolate to oblanceolate, sometimes abruptly-acuminate, usually gradually narrowing to the acumen which exceeds the calyx lobes in bud and equals or exceeds them at anthesis, usually abaxially reflexed in bud; distal portions usually ciliate, especially the margins, proximal portion usually glabrous, strongly clasping, slightly scarious

laterally; total length of the bract 3.2--4.2 mm, breadth 0.8--1.2 mm. Calyx tube \pm ten-ribbed, campanulate, oblique, slit dorsally to one-half its length, the margins of the slit ciliate; tube glabrous to puberulent, drying rufous, 2.4--2.8 mm long, 2.0--2.5 mm in diameter, usually possessing several yellowish glands lying between the calyx bundles; lobes drying black, spreading-ciliate, especially on margins, ventro-lateral lobes often directed slightly upward above the longitudinal calyx axis, leaving a gap between them and the ventral lobes, the ventral lobe 1.0--1.4 (2.0) mm long. Corolla rose-purple; standard blade rounded deltoid, sometimes slightly cordate, usually emarginate, 2.6--3.0 (3.2) mm wide, 2.7--3.1 (3.3) mm long; claw 3.0--4.0 mm long, emerging from the deep dorsal slit of the calyx; apical petals inserted at equal levels at the apex of androecial tube, blades oblong to slightly obovate, 3.3--4.2 mm long, 1.1--1.5 mm wide, claw 1.2--1.4 mm long. Androecial tube not exerted beyond the tip of the ventral calyx lobe at anthesis, 2.5--3.0 mm long; free filaments, 4.0--4.5 mm long. Carpel densely ciliate on distal half, especially on upper surface, 1.5 mm long, 0.8--0.9 mm in diameter; style inserted on the longitudinal axis of the ovary or slightly below, ciliate proximally for more than half its length, 4.0--4.5 mm long. Pod villous at the distal end, protruding from calyx at maturity, the beak projecting between the dorsal calyx lobes.

Distribution and phenology

Restricted to Nevada, western Utah, southeastern California and northwestern Arizona. An abundant species found in dry gravelly or sandy soil usually associated with sagebrush and juniper. Flowering beginning in late April, reaching a peak at mid May, ending by mid June.

Nomenclature and observations

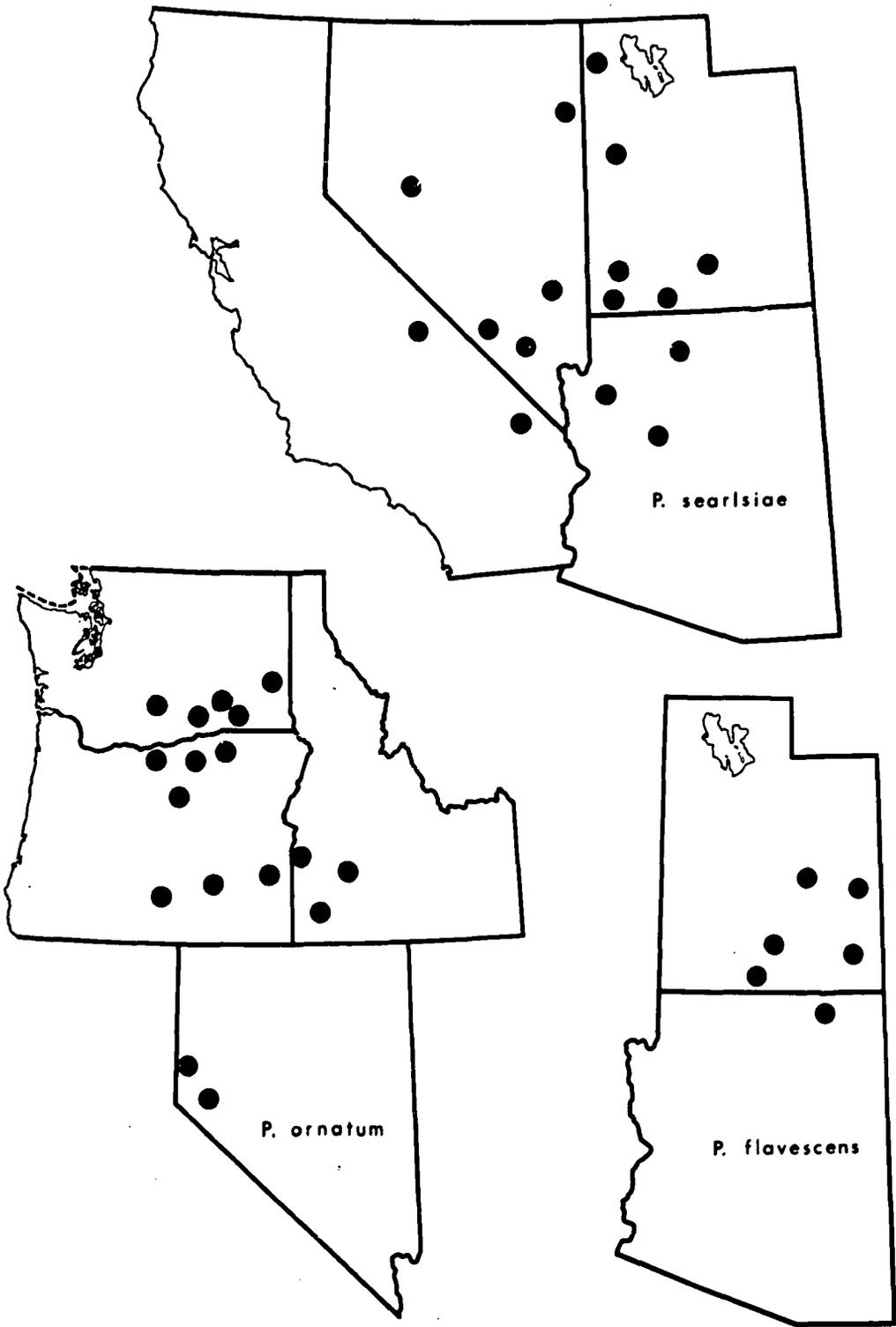
Rydberg distinguished Petalostemon rothroekii from P. searlsiae on the following characteristics:

	<u>P. rothroekii</u>	<u>P. searlsiae</u>
<u>Leaflets</u>	Oblong or linear oblong, obtuse or retuse, thick, 1 cm long.	Oblong or oblanceolate, involute on margins, acute at each end, 10--15 mm long.
<u>Spikes</u>	Cylindrical or oblong, 1.5 cm long, 8--9 mm wide.	Cylindrical, 1--4 cm long, 1 cm wide.
<u>Bracts</u>	Broadly obovate, short-acuminate, dark, short-pilose or glabrous.	Rhombic-oblanceolate, acute or short-acuminate, glabrous.
<u>Calyx</u>	3.5 mm long, lobes equalling tube.	4 mm long, lobes shorter than tube.
<u>Standard</u>	Broadly oblong-rounded or retuse at apex, truncate or subcordate, 3.5 mm, claw 5 mm long.	Broadly cordate, emarginate at apex, 3 mm, claw 4 mm long.
<u>Apical petals</u>	Oblong, acute at base 3.5 mm long, claw 2 mm long.	Oblong or obovate, 3--4 mm long, claw 1 mm long.
<u>Distribution</u>	Southern Utah and Arizona.	Southern Nevada, Utah and northern Arizona.

On the basis of my observations, bract shape is the only characteristic that shows a consistent regional variation. All other characters seem to fluctuate throughout the range of the species and perhaps represent various phenotypic combinations. The majority of specimens from extreme southeastern Utah (Washington and Kane counties), however, consistently have broader bracts, indicative of possible incipient regional patterning within the species. I have critically examined these specimens and find no further correlating characteristics that distinguish them from others throughout the range. This variation does not warrant specific ranking, nor from a practical standpoint, does it deserve varietal status. Bracts are early deciduous in this taxon -- they are lost shortly after anthesis of each flower; hence, spikes collected just past flowering or in fruiting condition lack the necessary identifying characters. I am of the opinion that the conservative inclusion of this variant within the confines of P. searlsiae is the best course of action. It is interesting to note that the type sheet (GH) containing Miss Searls' specimen from the Pahrnagat Mts., southeastern Nevada, also contains two southern Utah collections, Capt. F. M. Bishop, year, 1873 and Meehan year 1873. The latter specimen possesses the broad bracts, characteristic of Rydberg's P. rothrockii.

Petalostemon searlsiae is clearly distinct from P. ornatum even though the range of the two species is contiguous. P. searlsiae can always be distinguished by the possession of

Fig. 42. Geographical distribution of Petalostemon
searlsiae, P. ornatum and P. flavescens



an elongating spike 12 mm or less in diameter and a calyx slit dorsally to one-half its length, the slit ciliate at the margins. The calyx is neither thin and papery nor sericeous-pilose as in P. ornatum; rather, it is thick, drying rufous, glabrous or short-puberulant. P. searlsiae differs in so many ways from P. ornatum that it is indeed unlikely that they are closely related; however, their common relationship to P. flavescens of southeastern Utah provides justification for their inclusion in a common group, Compacti.

18. PETALOSTEMON FLAVESCENS Wats. (Fig. 42)

Petalostemon flavescens Wats. Amer. Nat. 7: 299-300. (1873). Type in GH. (1)(2).

Kuhnistera flavescens (Wats.) Kuntze. Rev. Gen. Pl. 1: 192. (1891). Based on Petalostemon flavescens Wats.

Description

Plants with stems 2--4 dm long, usually spreading-ciliate at base, becoming appressed-ciliate above, the entire stem covered with slightly protuberant glands. Stipules subulate, 2--4 mm long, ciliate. Leaves usually solitary, the rachis 1.5--2.5 cm long, often conspicuously gland-dotted, extended beyond the terminal pair of leaflets 1.0--1.7 mm; leaflets 5--7, elliptical to narrow-obovate, appressed-ciliate on both surfaces, rarely glabrous, 10--13 (16) mm long, 3--6 (7) mm wide, gland-dotted below, not above; often becoming con-

duplicately folded when dried, the midrib bending abaxially, the entire leaflet becoming falcate. Peduncle long, 7--15 (22) cm. Inflorescence a nonexpanding spike, 21--35 (55) mm long, 10 mm broad; rachis pubescent. Bracts narrow, lanceolate, only slightly expanded below the acumen, 5--8 mm long, 1.3--1.5 mm wide, exceeding the calyx lobes in bud, equalling or exceeding them at anthesis; proximal end "v shaped" in cross section, the midrib prominent, usually ciliate, margins glabrous and slightly scarious; distal portion flat, not concave or "v shaped," glandular, ciliate, narrowing to the acumen which is long-ciliate; small, paired, glandular bracteoles, 0.2 mm long, flank the base of the calyx. Calyx obviously ten-ribbed, the tube slightly thin-walled but not translucent, 2.6--3.0 mm long, streaked red, slit dorsally over one-half its length, the margin of the slit, ciliate, lobes lanceolate with ciliate, sometimes glandular margins, the ventral ones 1.5--2.5 mm long. Corolla yellow or yellow-white; standard oblong to rounded-deltoid, slightly cordate, emarginate at apex, 2.5--4.0 mm long, 1.5--3.8 mm broad, the claw 3.2 mm long; apical petals inserted at the same level but slightly below apex of staminal tube, oblong, cuneate at the base, 2.6--5.0 mm long, 0.9--1.7 mm wide, the claw 1.2--1.6 mm long. Staminal tube 2.9--4.5 mm long; free filaments 3.0--6.0 mm long; anthers pale yellow. Ovary elliptical, 1.5--2.3 mm long, 0.8--1.2 mm in diameter, ciliate on distal half, mostly ventrally; style 6.0--8.0 mm long, ciliate dorsally from

proximal end to half its length. Pod villous, not exserted beyond the calyx lobes at maturity.

Distribution and phenology

Rocky, sandy areas in southeastern Utah and northeastern Arizona. Apparently a very restricted and seldom collected species endemic to this area. Blooming time from late April to early June reaching a maximum in late May.

Observations

Petalostemon flavescens is highly variable for such a geographically restricted species. Vegetative pubescence varies from entirely glabrous to spreading-villous below and appressed-pubescent above. Floral parts also vary widely in size, and shape. Standard shape fluctuates from oblong (quadrilateral, as described by Watson for the type) to rounded-deltoid. One specimen examined (Holmgren & Goddard 9990, San Juan Co., Utah) possesses a highly glandular calyx with large spherical, translucent glands on the margins of the lobes -- strikingly different from others of the species.

Notwithstanding the individual variations, this species seems distinct and quite separate from others of this group. The closest affinities appear to be with P. searlsiae. The moderate pubescence (not long, sericeous-pilose cilia), glandular bracts, relatively thick-walled, dorsally split

calyx and the more oval ovary are characteristics in common. Similarity between the two species was noted by Jones (1895, p. 631) who wrote: "Petalostemon flavescens Watson seems to be a white flowered form of P. Searlsiae. I can see no other valid difference." Jones' remarks are reflected by Rydberg (1919-1920) following his description of P. flavescens: "(Perhaps not distinct from P. Searlsiae)." Despite this warning, Rydberg places P. flavescens in his "section" Compacti while placing P. searlsiae in Ornati.

P. flavescens is distinct from P. searlsiae on the basis of at least four characteristics. They are: 1.) possession of a nonexpanding spike; 2.) a yellow-white to white corolla contrasted with the purple corolla of P. searlsiae; and 3.) longer calyx lobes. Petalostemon flavescens also shows certain characteristics in common with P. ornatum and P. compactum. The petals of P. flavescens are inserted slightly below the apex of the staminal tube and the villous pod is not exerted beyond the apex of the calyx lobes at maturity. It seems reasonable, therefore, to include all these species in a single group, Compacti.

19. PETALOSTEMON ORNATUM Dougl. in Hook. (Fig. 42)

Petalostemon ornatum Dougl. in Hook. Flor. Bor. Am. 1: 138. (1830). Type in GL. (1)(2).

Dalea ornatum (Dougl.) Eaton. Man. Bot. for N. Am. 120. (1833). Based on Petalostemon ornatum Dougl.

Petalostemon macrostachyum of T. & G. Fl. N. Am. 1: 309. (1838). in part. Based on Petalostemum ornatum Dougl. Not Petalostemon macrostachyum Torr. (1828).

Kuhnistera ornata (Dougl.) Kuntze. Rev. Gen. Pl. 1: 192. (1891). Based on Petalostemum ornatum Dougl.

Petalostemon lagopus Rydb. Fl. N. Am. 24: 134. (1919-1920). Type in NY. (1)(2).

Petalostemon ornatus f. pallidus St. John. Northwest Sci. 2: 86. (1928). Type in WSP. (1)(2).

Description

Plants with reddish colored roots giving rise to numerous, glabrous, green-glaucous stems, 3--5 dm long, often corky below, moderately striate on lower portions, strongly striate above, dotted with slightly protuberant brown-red glands which are most pronounced and numerous at the stem apex. Stipules short, lanceolate, 1.2--2.2 (3.0) mm long. Leaves solitary at nodes; rachis to 4.0 cm in length, margined and glandular with prominent "stipel-glands" immediately below each petiolule insertion; rachis always extended 1.5--3.0 mm beyond the terminal pair of leaflets. Leaflets 5--7, varying in shape from broad-elliptic or broadly obovate to orbicular, 11--25 mm long, 6--12 mm broad, often emarginate, pale green and smooth above, gray-green and + prominently glandular below. Peduncles 2.5--10.0 cm long, usually at least one-fourth the total stem length; sterile bracts lacking below the inflorescence. Inflorescence a compact, non-expanding spike 12--16 mm broad and to 57 mm long in fruit, usually conical in bud; rachis

varying from glabrous to extremely pubescent. Bracts lanceolate, exceeding the calyx lobes in bud, equalling or exceeding them at anthesis, 0.8--1.8 mm wide, 4.0--5.6 mm long; proximal one-half clasping calyx, possessing a strong midrib and scarious lateral areas, usually glabrous but sometimes with a ciliate midrib; distal one-half flat, green, drying black, often with scattered glands, sericeous-long-ciliate, cilia to 1.5 mm long. Calyx tube campanulate, thin-walled often \pm transparent with dark colored vascular bundles, 2.6--3.8 mm long, covered with long appressed trichomes, often with rows of glands visible between vascular bundles; calyx lobes deltoid, green -- drying black, 1.2--2.0 mm long, sericeous, cilia to 1.8 mm in length. Corolla pale lavender; the standard 2.4--3.0 mm wide, 2.7--4.0 mm long, the base often slightly cordate, the apex entire or moderately emarginate, claw 4.5--6.0 mm long; apical petals oblong to slightly oblanceolate, often inserted slightly below the apex of the androecial tube, the central pair inserted lower than the lateral pair, 3.5--4.7 mm long, 1.4--2.1 mm wide, the claws 1.2--1.7 mm long. Staminal tube about 4.5 mm long, the free portion of the filaments 4.0--5.5 mm; anthers yellow. Carpel bearded, predominately so dorsally although \pm pubescent over entire distal one-half; ovary 1.8--2.2 mm long, 1.0 mm in diameter; style inserted on the carpel axis, 8.0 mm long, ciliate dorsally from the proximal end to about one-half its length. Pod not exerted from calyx tube at maturity,

this southern distribution is represented by only two collections. Rydberg (1919-1920) separated the two species as follows:

"Bracts lanceolate, long attenuate, much exceeding the buds or calyces.

39. P. ornatum, Oregon & Washington
Bracts broadly obovate, abruptly acuminate, scarcely exceeding the buds or calyces.

40. P. lagopus, Idaho, Nevada &
western Utah"

Among the plants examined from Washington and Oregon are to be found all shapes of bracts from narrow-lanceolate to rather broadly obovate, abruptly acuminate ones. Broad, short bracts, thus are not limited to the southern range. A further argument supporting merger of the two species is ecological. A finger of the "Sagebrush Steppe, Artemesia-Agropyron Association" extends south into western Nevada from the Columbia Plateau (Küchler 1964). Due to its southern occurrence, this material has been confused with P. searlsiae (Porter 1957). Specific differences between the two species are more fully discussed under P. searlsiae.

20. PETALOSTEMON COMPACTUM (Spreng.) Swezey (Fig. 43)

Petalostemon compactum (Spreng.) Swezey. Nebr. Fl. Pl. 1: 6. (1891). Based on Dalea compacta Spreng.

Dalea compacta Spreng. Syst. Veg. 3: 327. (1826).
(2)(4).

Petalostemum macrostachyum Torr. Ann. Lyc. Nat. Hist. N. Y. 2: 176-177. (1828). (2).

Kuhnistera compacta (Spreng.) Kuntze. Rev. Gen. 1: 192. (1891). Based on Dalea compacta Spreng.

Description

Plants with relatively few stems branching from an orange-red taproot, 3--5 dm tall, erect, branching above, glabrous, pale straw colored with prominent, slightly protuberant brown-red glands. Stipules 2.0--3.5 (5.5) mm long, subulate from a deltoid base. Leaves glabrous, 3.0--4.5 mm long; rachis extended 2--5 mm beyond terminal pair of leaflets; large "stipel-glands" often present immediately below the petiolule insertions; leaflets 7--9 (11), elliptical, acute, to 25 mm long and 6 mm wide, usually four times as long as wide; pale green and nonglandular above, gray-green and glandular-punctuate below, the glands generally restricted to areas near the margin or midrib. Peduncles 8--13 (15) cm long; glands protuberant, most numerous and pronounced near the apex. Inflorescence a non-expanding, compact spike beginning anthesis when 2 cm long but through further floral differentiation, attaining a length of 8--10 (12) cm with a breadth of 1.0--1.2 cm. Rachis 3 mm in diameter, densely spreading-villous, the

cilia immediately below flowers retrorse; frequently with a whorl of sterile bracts at the base of the spike. Fertile bracts exceeding calyx lobes in bud and at anthesis, narrow-lanceolate with a prominent midrib proximally, 6--8 mm long, 0.5 mm wide, pubescence, spreading villous-sericeous, covering the surface distally, restricted to midrib proximally especially pronounced at margins, the trichomes 1.5 mm long; calyx tube thin walled and relatively transparent, 1.8--2.2 mm long; vascular bundles drying red-black, visible through sericeous indument; lobes equalling tube, 1.6--2.2 (2.4) mm long, often not visible through the dense, spreading, cilia covering them. Corolla yellow-white (bluish in New Mexico ?); standard 1.8--2.2 mm long and as broad, rounded-deltoid, slightly cordate, the anterior margin often crenate; apical petals 2.0--3.2 mm long, 0.5--0.8 mm wide, oblong; claws 1.5 mm long, inserted just slightly below the apex of the staminal tube, all at the same distance from the floral base. Androecial tube 3.0--3.2 mm long; free filaments 3.0--3.4 (4) mm long. Ovary elliptical 1.8--2.2 mm long, 0.7--0.9 mm in diameter, long-ciliate on distal one-half; style 4.0--4.5 mm long, ciliate dorsally from the proximal end to one-third its length; stigma not exerted beyond anthers. Pod not exerted beyond the apices of the calyx lobes at maturity.

Distribution and phenology

Widely distributed but infrequent on the Great Plains from southwestern South Dakota to central New Mexico and west Texas. Apparently growing in a variety of habitats -- sand-hills, rocky slopes and knolls. Flowering time is sporadic, as early as late May and as late as late September. Maximum flowering is in mid to late July. The southern populations do not seem to flower earlier than those in the more northern part of the range.

Nomenclature and observations

The nomenclatural problems involved in the adoption of P. compactum (Spreng.) Swezey are discussed by Isely (1962). In summary, the Sprengel description is inadequate and the Sprengel herbarium was broken up in the 1860's and the portion assumed to possess the sought after material destroyed during World War II. P. macrostachyum, published two years subsequent to the Sprengel name is clearly identifiable but has not been used by twentieth century botanists due to its relegation to synonymy by both Swezey and Kuntze. As to why Swezey and Kuntze placed the Torrey name in synonymy is not clear -- neither offer an explanation. Isely concludes that it is probable that either of the two could have had access to the Sprengel specimens or at least information about them on which to base their decisions.

It is apparent that this taxon and P. ornatum are related.

Both possess similar bract and calyx pubescence, thin transparent calyces with red-black vascular bundles, petals inserted slightly below the apex of the androecial tube, elliptical carpels and pods not exerted beyond the calyx lobes. The relationship of these two taxa was first suggested by Heller on an annotation label placed on a New Mexico collection of P. compactum (Vasey 1881, Albuquerque). It reads: "Seems to be intermediate between K. ornata and K. compacta."

The corolla color of fresh material is said to be white to yellowish-white. When dried, the petals appear pale yellow. One collection from New Mexico (Ripley & Barneby 8347) seems to possess lavender petals. Close examination, however, shows it otherwise to fit clearly within the circumscription of P. compactum. An indication that the corolla color is not merely an artifact of drying is that Barneby assumed it to be P. tenuifolium -- a purple species. Although corolla color cannot be ascertained on the Vasey specimen it was perhaps corolla color that partially prompted Heller's comment.

21. PETALOSTEMON OBOVATUM T. & G. (Figs. 43, 54E)

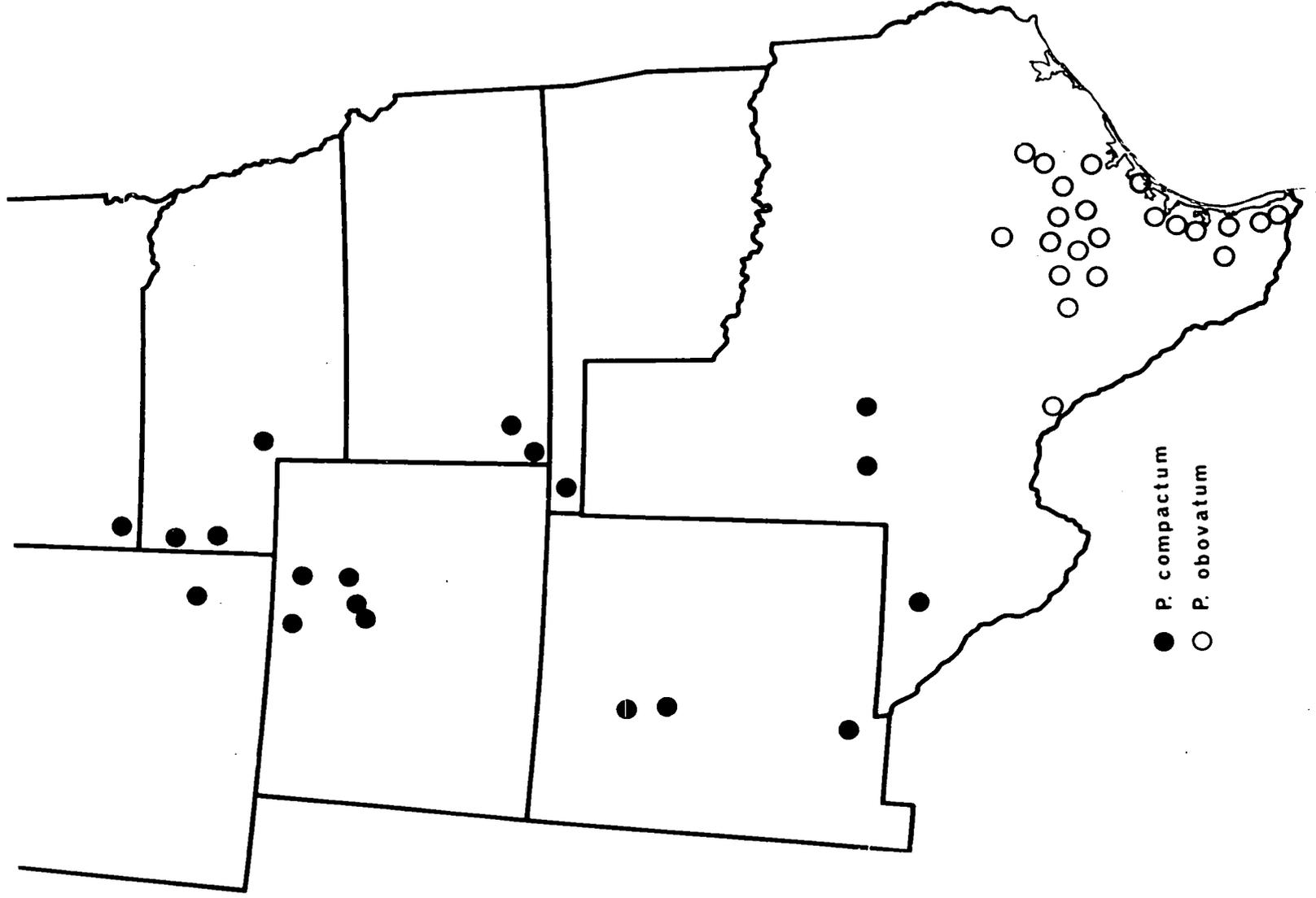
Petalostemon obovatum T. & G. Fl. N. Am. 1: 310. (1838).
Isotype in US. (1)(2).

Dalea agastachya Moric. Pl. Nouv. Am. 65-66, pl. 44.
(1839). Isotype in NY. (1)(2).

Kuhnistera agastachya (Moric.) Kuntze. Rev. Gen. Pl. 1:
192. (1891). Based on Dalea agastachya Moric.

Kuhnistera obovata (T. & G.) Heller. Bull. Torr. Bot.
Club. 23: 122. (1896). Based on Petalostemon obovatum
T. & G.

Fig. 43. Geographical distribution of Petalostemon compactum and P. obovatum



Description

Plants arising from a long, relatively unbranched, yellow-red taproot. Stems 4--5 dm long and to 6 mm thick at the base, decumbent and unbranched below, erect and often branched above, spreading pilose throughout their length. Stipules 4--7 (10) mm long, lanceolate from a broad base, spreading pilose. Leaves 3--4 (4.5) cm long, often deciduous on lower portions of stems; rachis extended beyond distal pair of leaflets 2.5--4.5 mm; leaflets (7) 9--11, 10--13 mm long, 5--8 mm wide, obovate, obtuse or emarginate at apex, appressed ciliate on both surfaces. Peduncles short or essentially nonexistent, a maximum of 1 cm long. Inflorescence a compact spike showing no rachis elongation in fruit but increasing in length due to apical floral differentiation following anthesis of lower flowers (spike then about 4 cm long), reaching a maximum of 8--10 cm in fruit, 1.4--2.0 (2.4) cm in diameter; inflorescence subtended by a whorl of sterile bracts. Fertile bracts concave, obovate, about 8.0 mm long, 3.3 mm wide, conspicuously glandular on the abaxial surface, pilose, spreading-ciliate, the trichomes 2.0 mm long; bract body 4.5 mm long, gradually tapering to an acumen 3.5 mm long, the tip drying dark red-brown; entire bract exceeding calyx lobes both in bud and in fruit; proximal portion of bract strongly "v-shaped"; margins scarious. Calyx tube transparent, spreading-villous, 2.2--2.5 mm long, the vascular bundles drying red, clearly visible through the dense pubescence; lobes plumose, equalling

or exceeding tube, subulate from a broad base, 2.0--3.0 mm long, the sinuses rounded between lobes. Corolla yellowish-white; standard 3.0--3.3 mm long, 1.6--1.8 mm wide, somewhat rectangular, truncate or slightly emarginate at apex, surpassing other floral parts following anthesis; claw 3.8--4.7 mm long; apical petals 2.8--3.4 mm long, 1.0 mm wide, rounded-oblong to obovate, the claws 0.6 mm long, inserted at the apex of the staminal tube. Androecial tube 4.6--5.0 mm long, the filaments 2.5--3.0 mm long, not spreading from longitudinal floral axis, the pale yellow anthers equalling the stigma in exertion. Ovary 1.6--1.7 mm long, 1.0--1.1 mm in diameter, densely villous in its entirety, the cilia especially prominent distally; style 5 mm long, ciliate only at the very proximal end. Pod spreading villous, not surpassing calyx lobes at maturity.

Distribution and phenology

Restricted to the "deep sands" (Gould 1962) of south Texas, usually growing in association with Dalea emarginata. Flowering from early April to mid July.

Nomenclature and observations

The publication of Moricand's Plantes nouvelles d'Amerique was spread over the years 1833--1846. There is no indication in the paper itself as to the dates of publication of the various parts. The exact date of publication of pp. 65--66 is

1839, according to Rickett and Stafleu (1961), thus confirming that found in Heller (1896). The epithet agastachya is therefore a later homonym.

This species is unique in that it sets seeds freely even in the absence of insect pollinators. The free filaments are very short and do not diverge from the longitudinal floral axis as in all other species. At anthesis, the style is shorter than the anthers but gradually elongates, passing through the pollen masses held by the filaments and anthers thus effecting pollination. Another unique characteristic is the long, plumose calyx lobes, reminiscent of those found in subgenus Kuhnistera. P. obovatum seems most closely allied with P. compactum. Both share: 1) indeterminate spike growth with flowers developing apically while fruits are falling from the rachis below; 2) clustered sterile bracts at the base of the spike; and 3) a densely villous-sericeous calyx with transparent tube and dark colored vascular bundles.

H. PURPUREI

Distinguishing characteristics

Leaves with (3) 5--9 (13) leaflets. Bracts and calyces with \pm appressed, usually short pubescence; calyces lacking prominent ribbing; corollas purple; anthers orange-yellow.

Distribution and ecology

Restricted to the Great Plains and Prairies. None extend west of the Continental Divide and few penetrate into the Gulf Coastal Plain. Most appear to be calciphilic, growing either on limestone substrates or calcareous prairie soils.

Observations

Even though some species characteristically have leaves with a maximum number of leaflets greater than 5, penta-foliate leaves predominate in this group. Trifoliate leaves are generally found only near the stem tips or stem bases (first formed leaves). Bract and calyx pubescence is short, often appressed, but sometimes spreading. Most species possess bracts that are glabrous except for a transverse belt of appressed cilia immediately below the base of the acumen, but in others, the bracts are uniformly pubescent. Calyx pubescence is uniform in some species but varying degrees of "balding" also occur. The extreme condition is reached in P. pulcherrimum, in which only an appressed fringe of hairs is found on the lateral margins of the calyx tube. In all species, the calyx is seldom prominently 10-ribbed, the vascular bundles supplying the lobes seem deeply imbedded within the tissues of the calyx wall and show little sclerification. P. tenuifolium shows moderate ribbing but it is generally concealed by the typical spreading pubescence of this species. All taxa possess a purplish corolla with a range between

species from pale lavender through blue to red-purple. There seems to be little variation within a single species and populations appear quite uniform in this characteristic. Compatibility tests carried on over the past three years have shown that all species of the complex are interfertile, furthermore, the progeny show no abnormal meiotic divisions or reduction in viable pollen.

There can be discerned three morphological units within the complex which are marked by variations in calyx shape. One group, perhaps the most generalized, is represented by P. purpureum, the most wide ranging species of the complex. This species possesses a tubular calyx of intermediate length (2.5--4.0 mm). The bract bodies are invested with a transverse belt of cilia, the remainder of the bract is glabrous.

P. gattingeri, P. tenue, P. arenicola, P. tenuifolium and P. reverchonii form another group, all possessing short (2.0--3.0 mm) campanulate calyces and narrow spikes. Generally the lobes are longer in relation to the calyx tube than in the other two groups. Even though uniform in major characteristics, there is considerable diversity within this group. For example, P. gattingeri, P. reverchonii and P. tenuifolium all possess a rachis that elongates following anthesis, while both P. tenue and P. arenicola retain a compact spike even in fruit. There is also variation in calyx pubescence, from the spreading investiture of P. tenuifolium to the retrorse cilia of P. tenue. Although leaflet number is quite homogeneous in

this group, the unusual, high leaflet number of P. reverchonii sets it quite apart from its associates. P. tenuifolium seems to represent the closest link to the P. purpureum tubular calyx form in closely resembling some of the "molle-pubescens" specimens of the western range of P. purpureum. The latter show a slight tendency for rachis elongation and short, almost campanulate calyx tubes, but retain all the other P. purpureum characters. On the other hand, P. tenue, even though specialized in the possession of retrorse pubescence, seems related in certain characteristics to the last unit of the complex, which is represented by P. decumbens and P. pulcherrimum. These two species have long, tubular parchment-like calyces which are basally rounded-deltoid in cross section and possess short, incurved lobes. The dorso-lateral lobes arise from flat surfaces and the three ventral lobes from the hemispherical lower part of the tube. The calyx of P. tenue is similarly shaped. Calyx pubescence is limited in both species: in P. pulcherrimum, it consists of a fringe along the lateral angles, in P. decumbens, of a distal-lateral fringe plus generalized pubescence toward the base of the calyx. Both species have glabrous ovaries or nearly so, a condition also found in P. tenue.

Hybridization in field populations of Petalostemon is apparently rare. I have observed it only in P. decumbens, P. pulcherrimum, and P. purpureum, and then only in the contiguous southeastern Oklahoma counties: Marshall, Bryan,

Choctaw and McCurtain. Hybridization between P. decumbens and P. purpureum was studied in Bryan, Choctaw and McCurtain counties during the summers of 1963 and 1964. Field recognition of the presumed hybrid swarms proved to be simple. Flower color variation ranged from characteristic blue of P. decumbens to the red-purple of P. purpureum. Bract shape varied from the precocious, long, abaxially bent P. decumbens type to the short, subulate-tipped bract of P. purpureum. Peduncle length varied from the very short or non-existent one of P. decumbens to the long, graceful peduncle of P. pulcherrimum. Sixteen mass collections were made during the two growing seasons. Analysis of eight will be presented here.

Although 20 characteristics were examined only 11 were used in the analysis presented. The ordinate of the graphs is the product of the calyx tube length and the ventral lobe length. The product provided a better graphic separation than the sum of the two or total calyx length. The abscissa is a composite scale of two variables, pubescence of the ovary and pubescence of the style. "Whiskers" are added for bract length, degree of development of the typical P. purpureum appressed-ciliate belt on the bract, peduncle length, rachis extension beyond the last pair of leaflets, inflorescence width and leaflet number. Lastly a subjective evaluation of calyx pubescence is presented. If the calyx was entirely appressed-pubescent as in "typical" P. purpureum, the circle is left clear. If the "typical" P. decumbens pubescence

pattern was present, with two prominent, lateral ciliate bands with a slight amount of intermediate ciliation at the base, the circle was blackened. Proportions of black and white indicate value judgements of hybridity. This judgement was made prior to graphing and thus has some degree of objectivity.

Figure 44 shows an analysis of eight mass collections illustrating hybridization between P. purpureum and P. decumbens. The first two (412 and 571) are pure populations of the two species in question; the others show varying degrees of introgression. Mass collections 604 and 605 show quite different population structures yet they were collected in the same area but from different sides of the highway. I do not believe that the striking differences are due to non-random selection because the two were quite different visually at the collecting site; rather, since pollinators move from one contiguous flower to another, the highway may have been a major isolation factor from the standpoint of pollination. Some time was spent in the area in 1964 observing and photographing the pollinators: Hymenoptera, Lepidoptera and some Diptera. These insects seemed to show no preference between the variants in the swarms. As previously indicated, I have synthesized hybrids between these species in the greenhouse and they match the intermediates found in field collections and show no reduction in fertility. All of the swarms were roadside populations -- growing in relatively disturbed habitats created by man. It is probable that in these environments the

hybrids compete successfully with the parents, and being fully fertile, persist.

Hybrids between P. pulcherrimum and P. purpureum were observed in Marshall county and studied by means of mass collection techniques. Three collections (59 specimens in all) were made in the vicinity of Madill, Oklahoma during the summer of 1963. All were from roadside populations which appeared intermediate between the two species in leaflet number, peduncle length and spike size. Twenty characteristics in all were studied and data is presented on twelve of them. Graphical analysis of these three mass collections in addition to two mass collections from adjacent areas of relatively pure populations of the putative parents is presented in Fig. 45.

Crosses between the two species synthesized in the greenhouse were morphologically identical with the intermediates seen in the field. The greenhouse progeny were fully fertile, underwent regular meiosis and set seeds normally. The swarms are evidently potentially self-perpetuating in an appropriate environment that allows the hybrid to compete on an equal basis with both parents. These conditions are apparently fulfilled only rarely in nature.

Voucher specimens of all the mass collections were deposited in ISC. They were selected to represent the wide variation range of each swarm and are so labeled.

Fig. 44. Graphic analysis of putative hybrid populations involving P. purpureum and P. decumbens.

412 and 571. Relatively pure populations of P. purpureum and P. decumbens.

579, 421-2, 424, 594, 604 and 605. Hybrid populations.

412. Wemple 412, 4.2 miles W Bokchito, Bryan Co., Oklahoma

571. Wemple & Jackson 571, 2½ miles W Soper, Choctaw Co., Oklahoma

579. Wemple & Jackson 579, 3 miles W Bokchito, Bryan Co., Oklahoma

421-2. Wemple 421-2, 2½ miles E US 70 & N, US 271, Choctaw Co., Oklahoma

424. Wemple 424, 3 miles E Hugo, Choctaw Co., Oklahoma

594. Wemple & Jackson 594, 3 miles W Ft. Towson, Choctaw Co., Oklahoma

604. Wemple & Jackson 604, 5 miles W Idabel, S side US 70, McCurtain Co., Oklahoma

605. Wemple & Jackson 605, 5 miles W Idabel, W side US 70, McCurtain Co., Oklahoma

The ordinate is the calyx length. The abscissa is the gynoeceal pubescence, the first abbreviation representing the condition of the ovary, the second, the condition of the style. BEARD, bearded; CIL, ciliate; GLAB, glabrous.

The degree of darkening of the circle represents a subjective estimate of the degree of "decumbens-like" calyx pubescence

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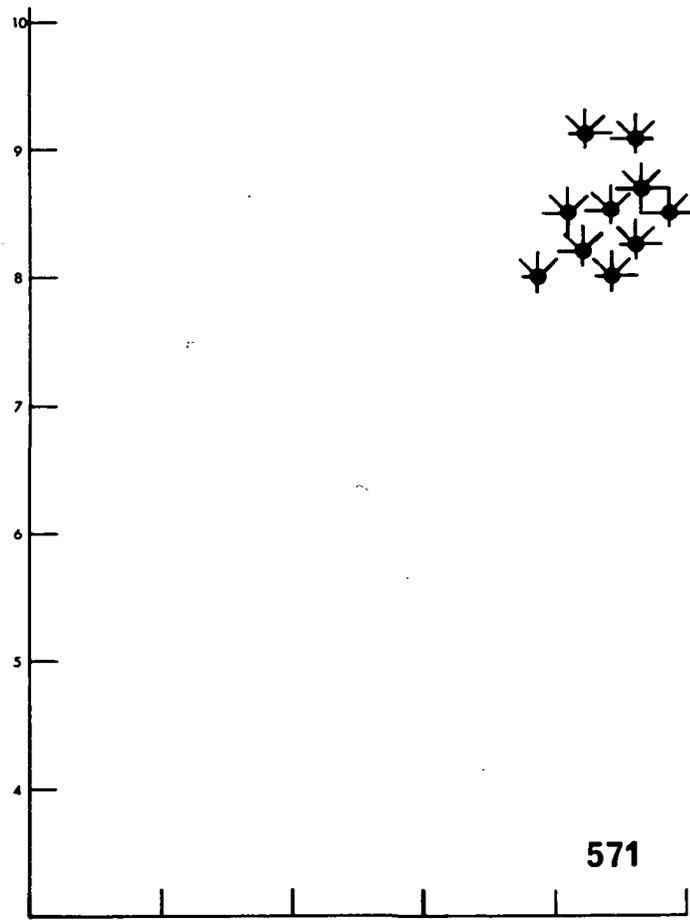
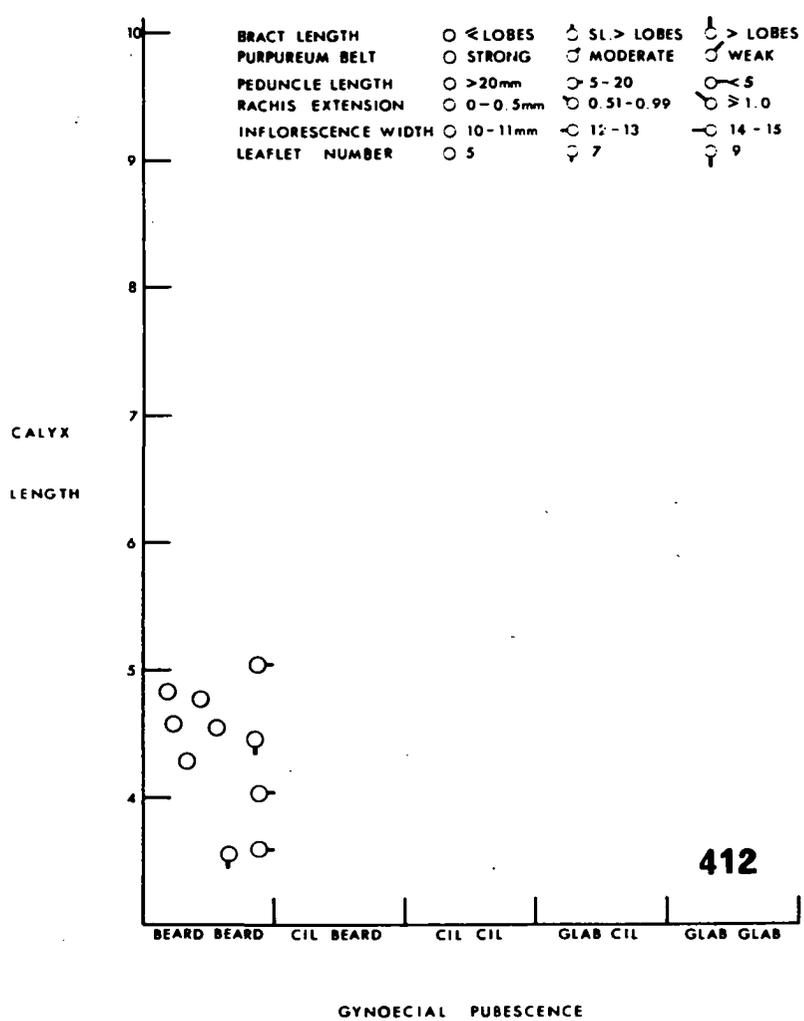


Fig. 44 (Continued).

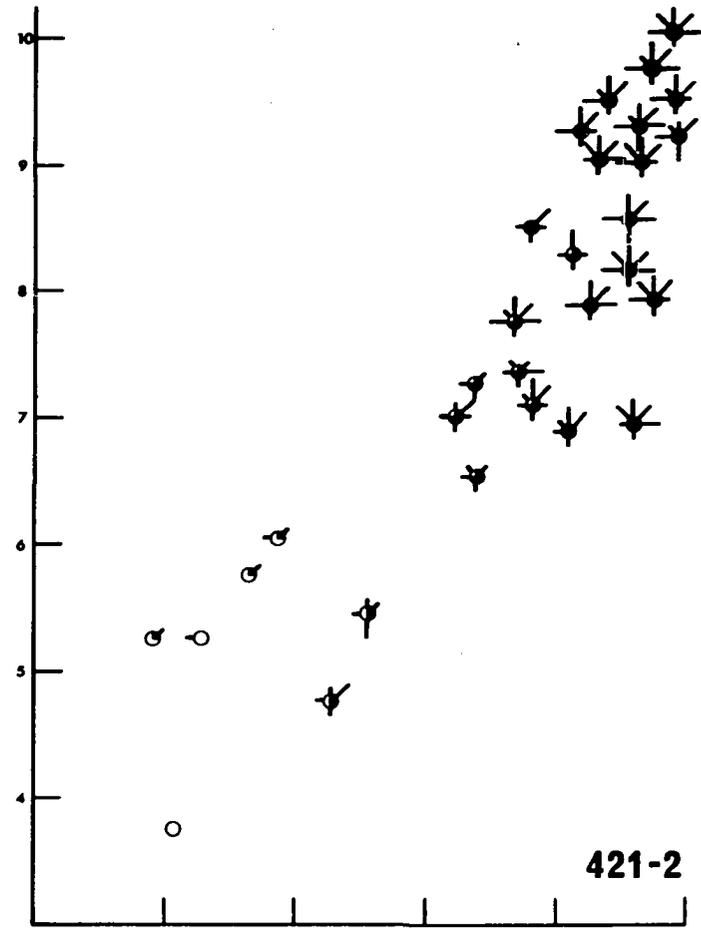
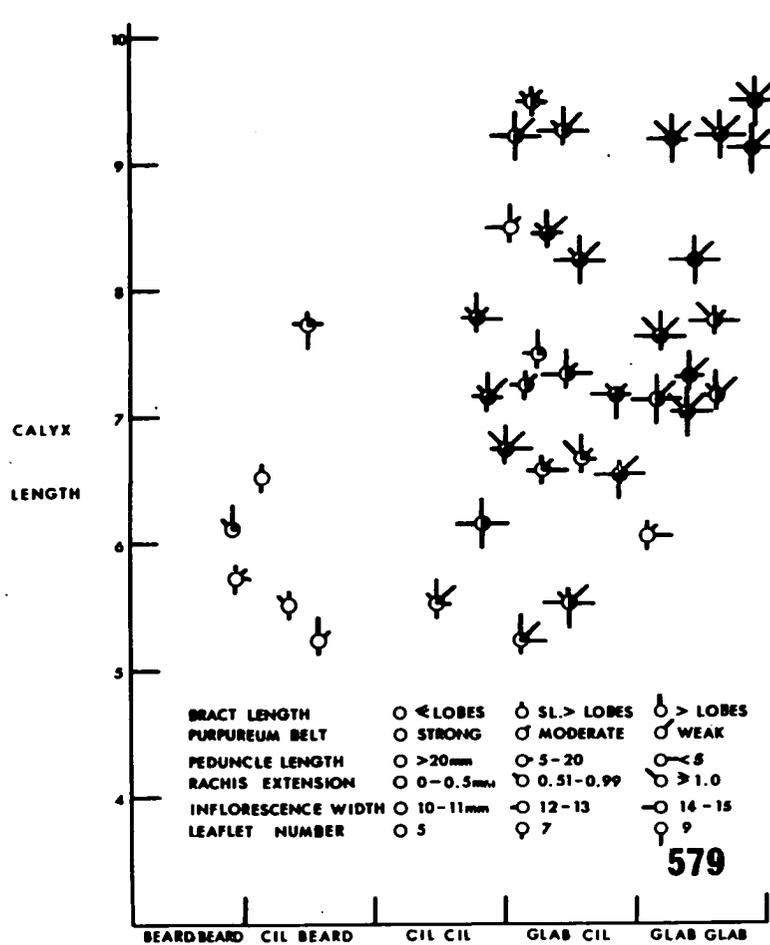
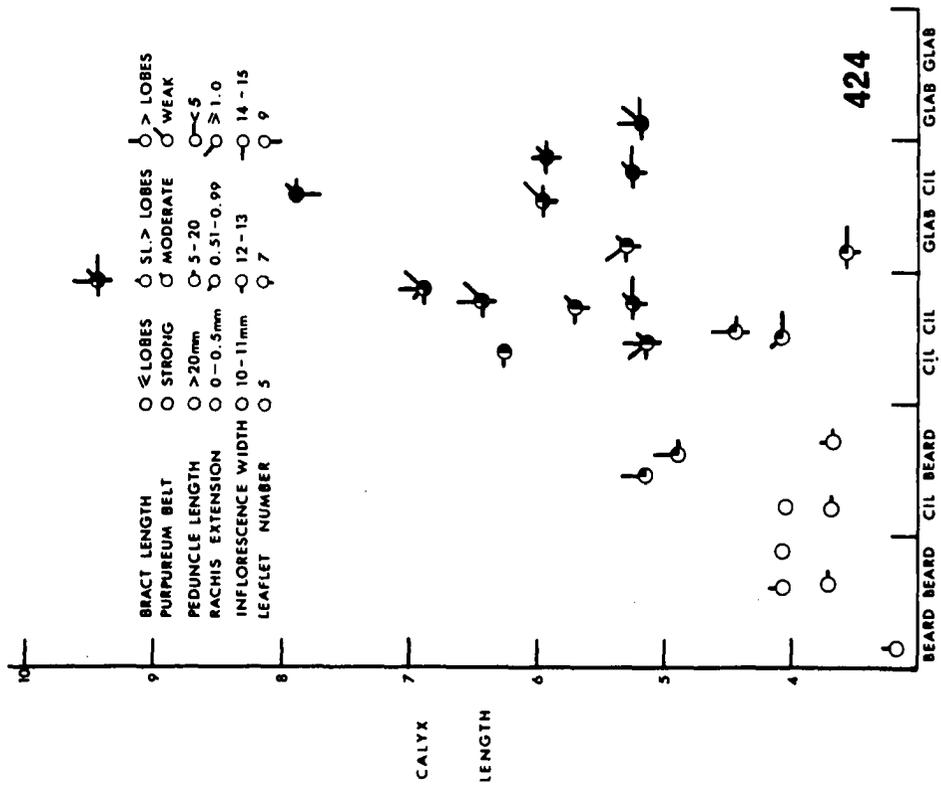
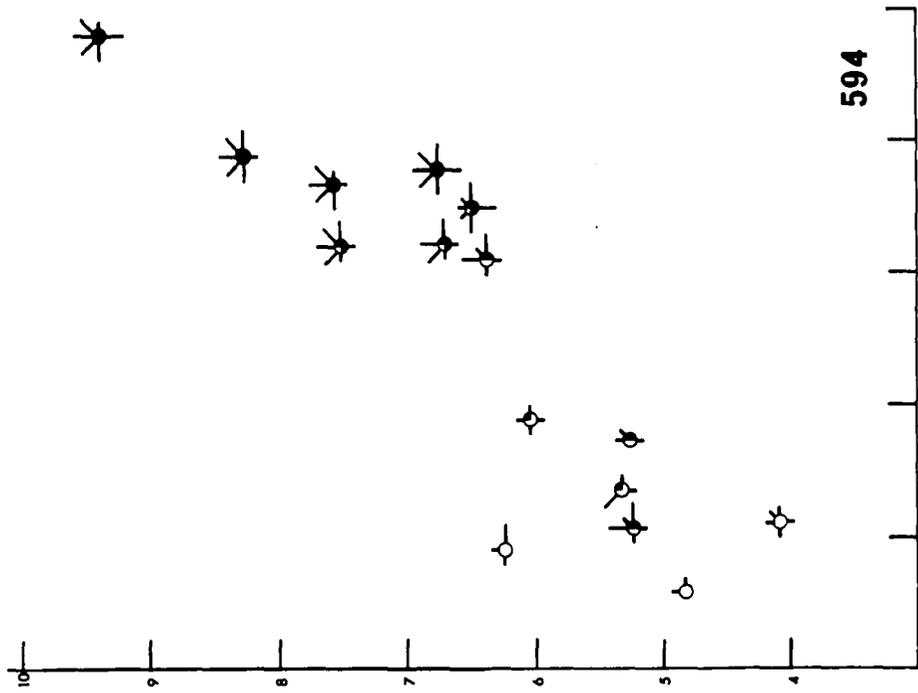


Fig. 44 (Continued).



- BRACT LENGTH ○ ≤ LOBES ○ SL. > LOBES ○ > LOBES
- PURPUREUM BELT ○ STRONG ○ MODERATE ○ WEAK
- PEDUNCLE LENGTH ○ > 20mm ○ 5-20 ○ < 5
- RACHIS EXTENSION ○ 0-0.5mm ○ 0.51-0.99 ○ ≥ 1.0
- INFLORESCENCE WIDTH ○ 10-11mm ○ 12-13 ○ 14-15
- LEAFLET NUMBER ○ 5 ○ 7 ○ 9

GYNOECIAL PUBESCENCE

BEARD BEARD CIL BEARD CIL CIL GLAB CIL GLAB GLAB

Fig. 44 (Continued).

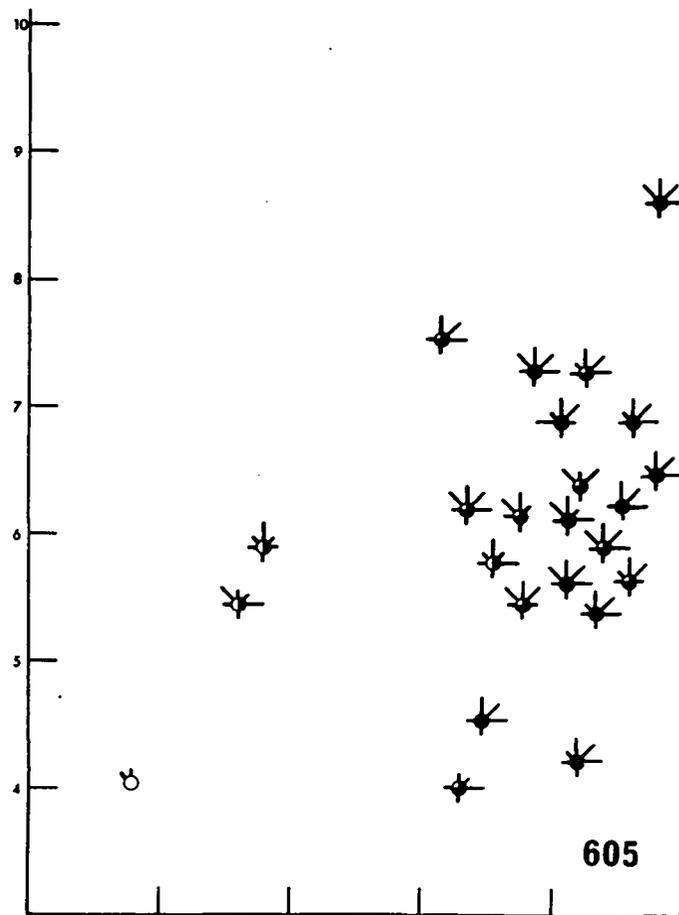
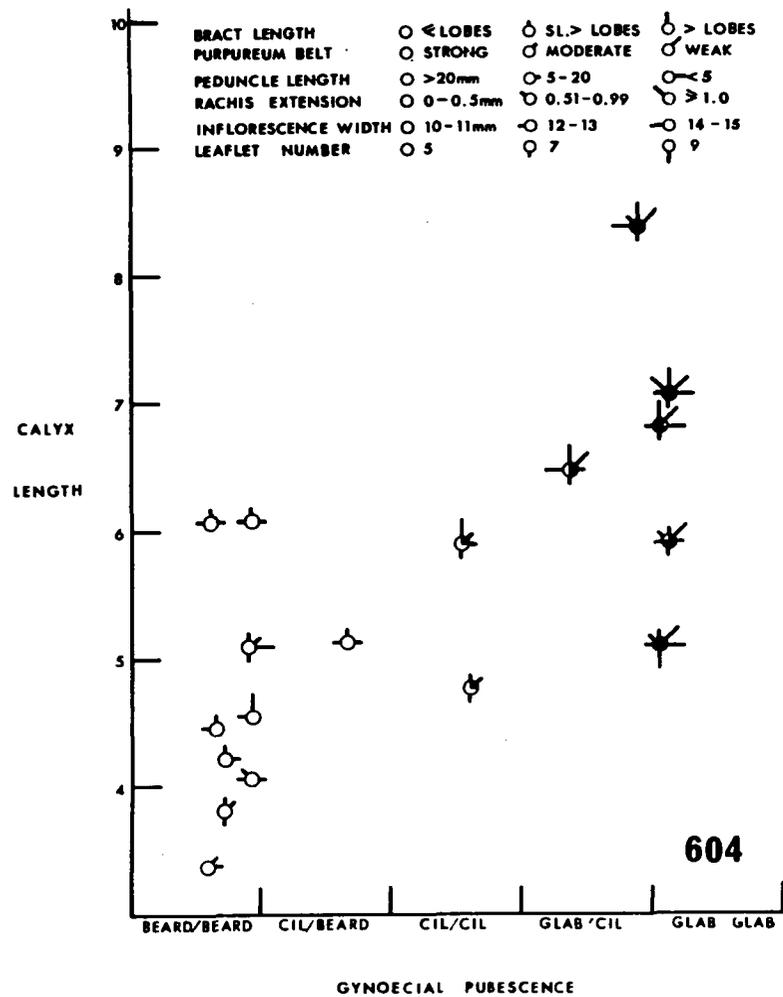
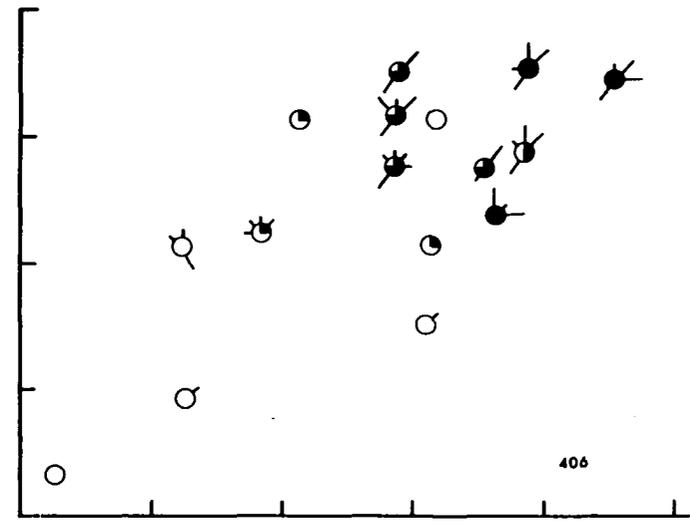
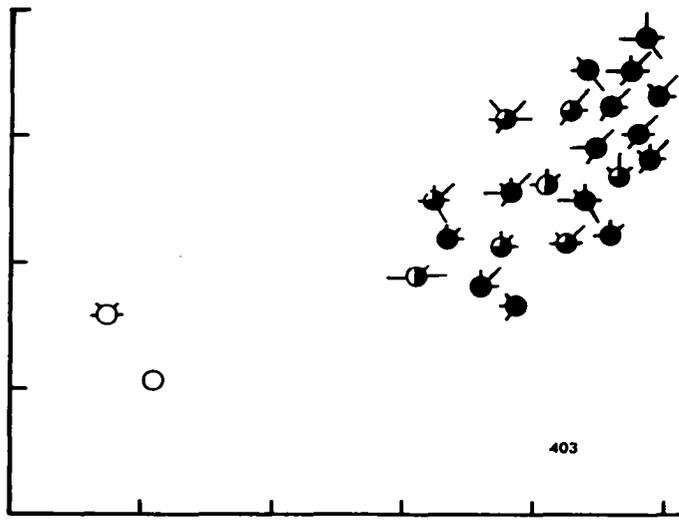
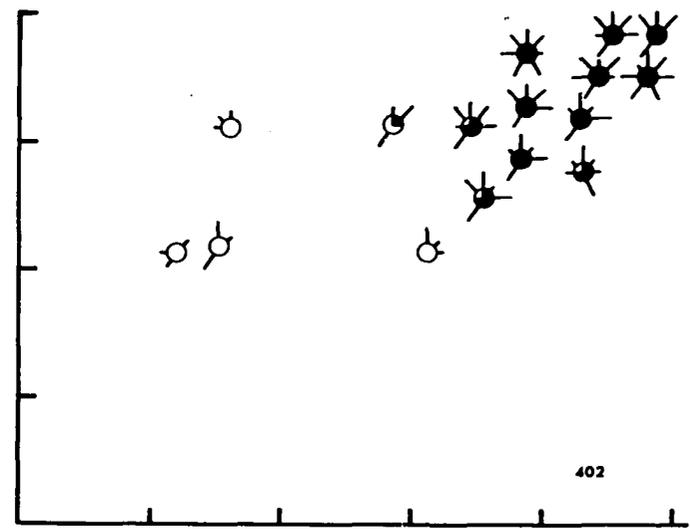
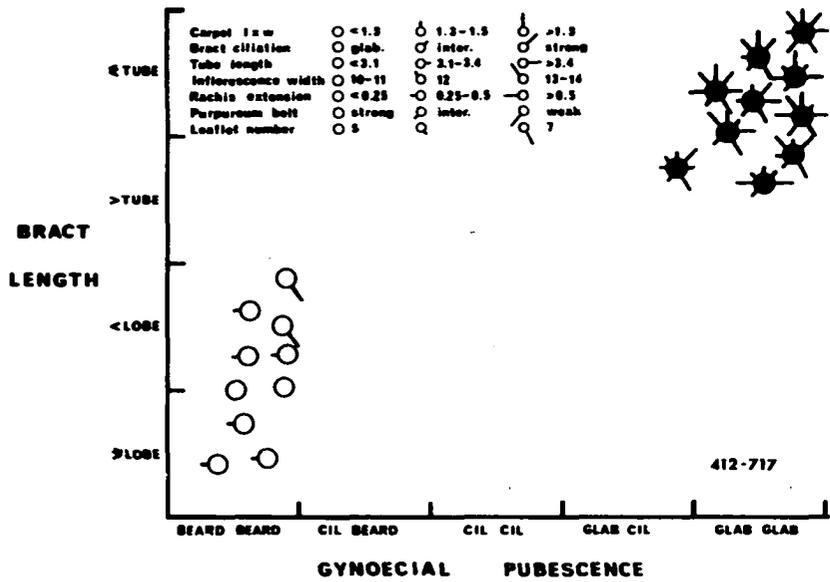


Fig. 45. Graphic analysis of putative hybrid populations involving P. purpureum and P. pulcherrimum.
412-717. Relatively "pure" populations of P. purpureum (lower left) and P. pulcherrimum (upper right).
402, 403 and 406. Hybrid populations.

412. Wemple 412, 4.2 miles W Bokchito, Bryan Co., Oklahoma
717. Wemple & Jackson 717, 7 miles E Navasota, Grimes Co., Texas
402. Wemple 402, 3 miles NW Madill, Marshall Co., Oklahoma
403. Wemple 403, 1 mile SE Madill, Marshall Co., Oklahoma
406. Wemple 406, 6 miles SW Madill, Marshall Co., Oklahoma

The ordinate is bract length relative to the calyx tube and ventral lobe. The abscissa is gynoeical pubescence, the first abbreviation representing the condition of the ovary, the second, the condition of the style. BEARD, bearded; CIL, ciliate; GLAB, glabrous.

The degree of darkening of the circle represents a subjective estimate of the degree of "pulcherrimum-like" calyx pubescence of each specimen



Key to the Species

1. Rachis elongating following anthesis, the raceme becoming lax; bracts fugacious, evenly pubescent, the cilia not restricted to a narrow, transverse, appressed band at the base of the acumen; calyx evenly pubescent with short, spreading indument.
2. Leaflets 9--11 (13); stems less than 2 dm tall; rare, known only from type locality, Hood Co., Texas.
 22. P. reverchonii p. 227
2. Leaflets 3--9; stems longer than 2 dm; not restricted as above.
 3. Leaflets 3--5; stem base and apex of long peduncle with dense spreading pubescence; bracts 2 mm broad or more; north Texas and adjacent areas.
 23. P. tenuifolium p. 232
 3. Leaflets 7--9; stem glabrous at base becoming slightly ciliate above, usually densely ciliate at apex of the short peduncle; bracts less than 2 mm broad; central Tennessee, northwest Georgia and Alabama.
 24. P. gattingeri p. 237
1. Rachis not elongating following anthesis, the raceme remaining compact; bracts persistent, not evenly pubescent, the pubescence restricted to a narrow, transverse,

appressed band at the base of the acumen; calyx often unevenly pubescent, the cilia \pm appressed.

4. Pubescence on distal $2/3$ of calyx tube restricted to two bands of appressed cilia on lateral angles; spikes at anthesis usually 12 mm or more in diameter; leaflet number 7--9; restricted to southeastern Oklahoma and Texas.

5. Bracts shorter than calyx lobes at anthesis; leaflets less than 3 mm wide; peduncles 4 cm or longer; east-central Texas and adjacent counties in southern Oklahoma.

25. P. pulcherrimum p. 243

5. Bracts equalling or exceeding calyx lobes at anthesis; leaflets wider than 3 mm; peduncles 3 cm or less, spikes often sessile; restricted to southeastern Oklahoma and southeastern Texas.

26. P. decumbens p. 252

4. Pubescence on distal $2/3$ of calyx tube not restricted to lateral bands; spikes at anthesis usually less than 12 mm in diameter; leaflet number usually 5, rarely 7; not geographically restricted as above.

6. Plants \pm pubescent with stems longer than 3.5 dm, usually branching above; peduncles

short, less than 1/4 the length of the stems; spikes at anthesis 10 mm in diameter or wider; widespread from Canada to north Texas and Illinois to Colorado.

27. P. purpureum p. 255

6. Plants usually completely glabrous with stems shorter than 3.5 dm, usually unbranched above; peduncles long, usually exceeding 1/4 the length of the stems; spikes at anthesis narrower than 10 mm; restricted to Texas and the Llano Estacado.

7. Proximal calyx pubescence retrorse, directed toward the rachis; ovary glabrous or nearly so; central and east-central Texas.

28. P. tenue p. 263

7. Proximal calyx pubescence antrorse, directed away from the rachis; ovary bearded; Llano Estacado.

29. P. arenicola p. 271

22. PETALOSTEMON REVERCHONII Wats. (Figs. 46, 53E)

Petalostemon reverchoni Wats. Proc. Amer. Acad. 21: 449. (1886). Type in GH. (1)(2).

Kuhnistera reverchoni (Wats.) Heller. Bull. Torr. Bot. Club. 23: 124. (1896). Based on Petalostemon reverchoni Wats.

Dalea reverchoni (Wats.) Shinnars. Field and Lab. 17: 84. (1949). Based on Petalostemon reverchoni Wats.

Description

Stems multiple, arising from a stout rootstock, 1--2 dm long, ± densely appressed-pubescent, striate, with three prominent ribs below each leaf. Stipules persistent, subulate, to 3 mm in length. Leaves glabrous to glabrate, fascicled, bearing 9--11 (13) linear-elliptical, involute leaflets 5--8 mm long, 1.5 mm wide, glabrous, pale, and nonglandular above, slightly ciliate, darker, and prominently glandular below. Peduncles short, less than 10 mm in length. Inflorescence an expanding spike originating as a subglobose bud, attaining 7 cm in fruit, 1 cm thick. Bracts fugacious as rachis elongates, precocious, becoming shorter than calyx lobes at anthesis, pubescent over the entire distal portion, the cilia not restricted to a narrow band, ciliate-fringed on proximal margins. Calyx tube campanulate, evenly short-spreading -- to slightly appressed-pubescent, 2.2 mm long, 2.4 mm in diameter; ventral lobe 1.8 mm long. Corolla deep pink or reddish, standard not lobed at base nor emarginate at apex, 2 mm wide, 2 mm long; apical petals oblong, 2.5 mm long, 0.9 mm wide.

Ovary slightly pubescent distally and ventrally, style inserted above the longitudinal axis. Pod developing ventrally and distally, pushing up between dorso-lateral lobes in fruit.

Distribution and phenology

Known only from the type locality, Comanche Peak, Hood Co., Texas. The two (three?) collections were made in June, the one labeled 5 June 1900 by H. Eggert, is in bud; the other, simply labeled June by J. Reverchon, 1882, has some spikes initiating anthesis and some in full fruit.

Nomenclature and observations

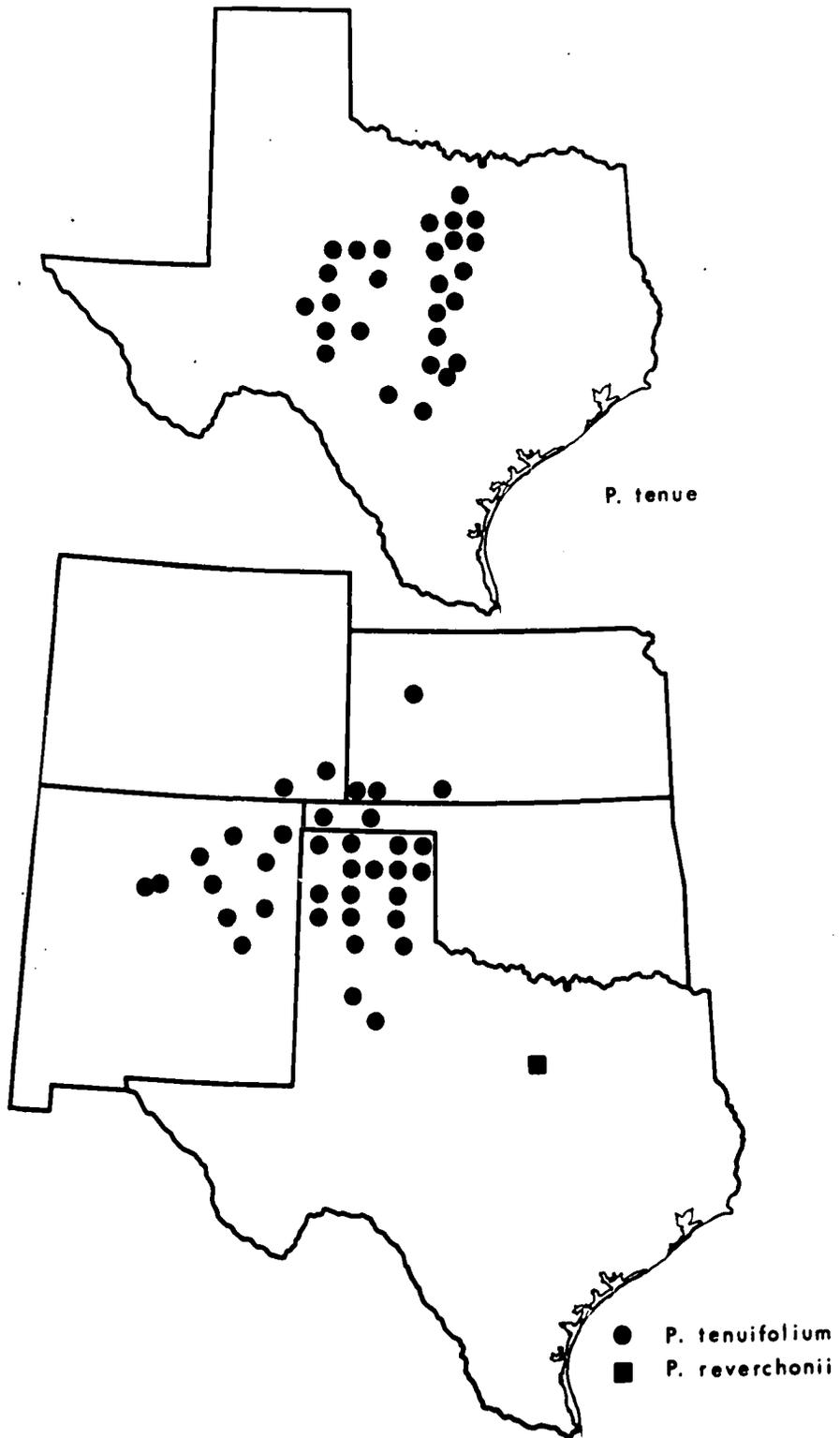
According to the description, the type collection was, "-- On the rocky top of Comanche Peak, in western Texas; J. Reverchon. June 1882 (n. 36)." I have seen two collections labeled No. 36. I accept as the type the specimen in GH; the other, an isotype, is at SMU. There are three additional Reverchon sheets also labeled Comanche Peak, June 1882 but numbered 1273, in NY, MO, and US. It is possible that there was a discrepancy in Reverchon's numbering system. For the present these sheets are assumed to be topotypes. The last collection of this taxon was in 1900 by H. Eggert (MO). This specimen, collected 5 June 1900 is in bud, clearly showing the precocious development of the bracts. The Reverchon specimens are, for the main part, fully in fruit but do possess small, secondary, axillary spikes at anthesis. There are few flowers

on the latter spikes but the corolla color is retained. The corolla dimensions used in the description were extrapolated from a floral drawing on a Reverchon, 36 sheet in NY. The drawing of the calyx on that sheet is quite accurate and I have assumed the same to be true of the corolla. I have compared this artist's drawings on other sheets with my own observations and found them consistently accurate.

P. reverchonii represents somewhat of an enigma. It fits clearly within this section of the genus on all characters except leaflet number and the possession of pubescent stems while having relatively glabrous foliage. It has the elongating rachis characteristic of P. tenuifolium, yet the restricted bract pubescence and ciliation of P. arenicola. It is clearly related to the latter two species as well as P. tenue on the basis of calyx shape. Its location is within the current geographic range of P. tenue and apparently occupies the same "ecological niche." Evidence for this is given by Shinnars (1949b), who says;

This is one of the most highly restricted endemics in north Texas. Comanche Peak is a massive, flat-topped outlier capped by one of the resistant limestone formations which make up the Edwards Plateau farther south and west. On the Edwards Plateau, the Comanche Peak limestone lies beneath other beds, but is exposed at many places in the intervening 'Lampasas Cut Plain' and elsewhere. Quite possibly the actual range of

Fig. 46. Geographical distribution of Petalostemon tenue,
P. tenuifolium and P. reverchonii



Dalea Reverchonii is greater than known at the present.

The "Lampasas Cut Plain" of which Shinners speaks is a portion of that area occupied by the eastern distribution of P. tenue.

Turner (1959, pp. 165-166) comments, "It is close to P. purpureum and P. pulcherrimum but seems to have a combination of characters that mark it distinct. However, detailed study of the entire P. purpureum complex may necessitate a change in its status." My study does not indicate that any change is in order regarding the status of P. reverchonii -- it is distinctive but appears to belong clearly in the P. purpureum complex.

It is quite possible that P. reverchonii is no longer extant. Unlike P. sabinale, also a very rarely collected Texas endemic, P. reverchonii is not indigenous to a relatively remote, inaccessible area. Considering the close proximity to major botanical institutions, it seems unlikely that this species would not be collected if it was still in existence.

23. PETALOSTEMON TENUIFOLIUM Gray (Figs. 46, 53A)

Petalostemon tenuifolius Gray. Proc. Amer. Acad. 11: 73-74. (1876). Type in GH. (1)(2).

Kuhnistera tenuifolia (Gray) Kuntze. Rev. Gen. Pl. 1: 192. (1891). Based on Petalostemon tenuifolius Gray.

Petalostemon porterianus Small. Fl. S. E. U. S. 631. (1903). Original material in GH. (1)(2).

Dalea tenuifolia (Gray) Shinnars. Field and Lab. 17: 84. (1949). Based on Petalostemon tenuifolius Gray.

Description

Stems moderately striate, 2--5 dm tall, often branching above, slightly pubescent overall, with dense spreading cilia (to 0.5 mm long) prominent at the stem base and again just below the inflorescence. Stipules subulate, dark, to 5 mm long. Leaves fascicled; leaflets linear, 3--5, slightly ciliate at margins, involute, often curving when dried. Peduncles variable in length, 0.9--12.5 cm, elongating in age. Bracts precocious, exceeding the calyx lobes in bud, usually deciduous by anthesis, concomitant with rachis elongation; not clasping calyx at base nor strongly keeled, 2 mm broad or greater at expanded portion, 2.5--3.0 mm long, narrowing gradually to the dark, subulate acumen, 0.7--0.9 mm long; entire surface evenly pubescent; anterior edge rounded, ciliate-fringed. Inflorescence globose in bud, becoming columnar; rachis elongating following anthesis, the raceme becoming lax and often sinuous, up to 10 cm long, 7--10 mm wide. Calyx ten-ribbed, often barely visible through spreading pubescence of hairs up to 1 mm long; tube campanulate, 2.4--2.8 mm long; dorso-lateral lobes deltoid, ventro-lateral and ventral lobes lanceolate, the latter 1.7--2.0 mm long. Corolla violet to purple; standard blade 2.0--2.2 mm long, 2.0--2.3 mm wide, strongly auricled, the claw 2.2--3.3 mm long;

apical petals inserted slightly below the apex of the staminal tube in prominent sockets, the blades 3.0--3.5 mm long, 1.0--1.5 mm wide, squared at the base but not auricled, claws 0.7--1.3 mm long. Anthers extended slightly farther than petal apices; pollen a bright yellow. Ovary 1.9--2.2 mm long, 0.8--1.1 mm in diameter, densely bearded on the distal one-half, the beard most prominently developed ventrally; pubescence continuing distally on the dorsal surface of the style for slightly over one-half its length; style inserted above the longitudinal axis of the carpel and in fruit directed upward at a 45° angle due to ventral development of the pod.

Distribution and phenology

Southwestern Kansas, southeastern Colorado, northeastern New Mexico and the panhandles of Oklahoma and Texas. Growing in rocky limestone soils usually in unprotected areas. Initiating anthesis in early May but not reaching maximum until early June, then tapering off until late July. A few collections have been made even later in the season, perhaps flowering at this time due to late season rains.

Nomenclature and observations

A single type sheet bearing specimens representing all the names that have been applied to this taxon is in GH. The primary label at the lower right hand corner reads,
"Petalostemon tenuifolius n sp., Dr. J. T. Rothrock, No. 81,

Explorations and Surveys West of the 100th Meridian, Corps of Engineers, U. S. Army, Expedition of 1874." Four specimens on the right side of the sheet (an entire branch, composed of five stems, and three separate stems) are mounted over the penned inscription, "Crossing of Red River, Arkansas, Dr. Newberry." At the upper left hand corner of the sheet is a handwritten note signed by T. C. Porter reading:

Petalostemon [in ink] Searlsiae ? [in pencil]
Dalea ? Allied to D. filiformis, Gr. (Pl. Wright. l. p. 39) but differs: Fruticulose at base -- pubescent -- leaves glandular -- bracts broadly ovate and cuspidate -- flowering spike larger and fruiting ones larger, 1'--3'. On route from Leavenworth to El Paso. Legit F. R. Dieffendorfer.

All of this coincides with Gray's complex type citation in the description as, "-- Arkansas, at the crossing of Red River, Dr. Newberry; New Mexico, Mr. Dieffendorfer (ex T. C. Porter), J. T. Rothrock."

That this sheet also contains material referable to a type of P. porterianus Small, is less clear. Small names no type nor does he cite specimens. He merely states, "On prairies, Arkansas, Summer." Further, there is apparently no material in NY annotated by Small as P. porterianus. The principal clue then is that the name suggests a Porter collection or at least one on which Porter supplied the information. Apparently of this mind, Rydberg (1919-1920) supplies

typification somewhat by stating at the close of his description, "Type locality: 'Leavenworth, Arkansas, to El Paso, Texas'." I take this to mean a designation by Rydberg of this specimen. In corroboration is a pencilled arrow pointing to a stem below Porter's note on the subject sheet, followed by, "P. porterianus Small", signed "PAR" in Rydberg's hand. Inasmuch as Rydberg's interpretation is plausible and the specimen is consistent with Small's description, acceptance of this specimen as the type seems reasonable.

The primary difference among the specimens on this intricate sheet is that the calyx ribs are slightly more prominent on that presumed to represent P. porterianus than that of P. tenuifolium. This, in fact, was the main criterion on which the separation of the two was originally based. My experience has indicated that throughout the range of P. tenuifolium the calyx is ribbed, but spreading pubescence often obscures this fact. The specimen on the left of this sheet (that representing P. porterianus) is more mature; the spikes have lost their bracts and the calyces some of their pubescence: therefore, the calyx ribbing is easily visible. The other differences stated by Small and amplified by Rydberg are well within the range of P. tenuifolium as I understand it.

The range of P. tenuifolium is the southern part of the Llano Estacado and west into northeastern New Mexico. In parts of its range it is sympatric with P. purpureum and P. arenicola. It can readily be distinguished from both by its unique

rachis elongation and spreading pubescence at the stem base.

The habitat preference of P. tenuifolium is on the mesa tops, the limestone cap rocks of the Llano Estacado. This contrasts with the habitat preference of P. arenicola, the sandy stream beds dissecting this area, and that of P. purpureum, the relatively rich but rare prairie soils of this general area.

P. tenuifolium is the only species in section Purpurei showing petal insertion slightly below the apex of the staminal tube. This characteristic is considerably more common in section Ornati. In all other characteristics, however, P. tenuifolium clearly fits into the Purpurei. The occurrence of this presumed "daleoid" characteristic in two sections of Petalostemon (and among species clearly Petalostemon on the basis of other characters) strongly suggests that this type of petal insertion is a secondarily derived feature. There is no indication of affinity with those Daleae with subterminal petal articulation.

24. PETALOSTEMON GATTINGERI (Heller) Heller (Figs. 47, 53P)

Petalostemon gattingeri (Heller) Heller. Bull. Torr. Bot. Club 26: 593. (1899). Based on Kuhnistera gattingeri Heller.

Kuhnistera gattingeri Heller. Bull. Torr. Bot. Club 23: 121 & pl. 262. (1896). Type in US. (1)(2).

Description

Root black, massive and highly ramified, usually branching laterally immediately below the caudex. Stems many, branched, 2--4 dm long; glabrous and round at the base, becoming slightly ciliate and striate above, usually drying to a pale, straw color; outer ones usually prostrate, inner ones erect, plants forming low growing mats. Stipules subulate, 5--7 mm long, persistent and drying straw colored. Leaves fascicled, the major leaf often with two minor trifoliate axillary leaves, occasionally an entire compressed branch system; mature leaf rachis to 20 mm in length bearing 7--9 narrow-lanceolate leaflets which are 10--14 mm long, 0.9--2.3 mm wide, usually near 1 mm, the wider leaflets restricted to leaves at base of stem; leaflets moderately involute, drying pale green above, darker below with small, red glands visible only on the lower surface. Peduncles short, less than 3 cm, often lacking; apex becoming densely ciliate. Inflorescence an expanding columnar spike often becoming sinuous in fruit, 70 mm in length, never exceeding 10 mm in width. Bracts precocious, far exceeding the calyx lobes in bud and equalling or slightly exceeding them at anthesis, fugacious as spike expands; body 1.5 mm long, elliptical, not tightly compressing calyx at base; bract pubescence evenly spreading over distal surface, not restricted to a narrow belt; distal-lateral margin fringed, the proximal end glabrous; acumen subulate, to 6 mm, often ciliate and recurved abaxially, especially in bud. Calyx tube

campanulate, 10-ribbed, 2.0--2.6 mm long, evenly, densely pubescent; trichomes 0.7 mm long, drying silvery over the pale rust colored tube; lobes evenly ciliate, lanceolate, often spreading away from longitudinal calyx axis, the ventral lobe 1.7--2.5 mm, green color persistent through drying. Corolla pale to deep purple; standard blade 2.3--2.6 mm wide, 1.4--2.0 mm long, deltoid, not auricled at base, the distal margin entire; claw 3.0--4.0 mm long; the apical petal lamina oblong-elliptical, 3.0--3.4 mm long, 1.3--1.4 mm wide, the claws 1.2--1.3 mm, cuneate at lamina base. Androecial tube 3.2 mm long, not exerted beyond calyx lobes; filaments 5.0--5.5 mm, purple, exerted beyond petal apices; anthers yellow-orange with lateral dehiscence lines bright red; pollen a bright orange. Ovary 1.2 mm long, 1.0 mm in diameter, strongly bearded on the distal-ventral two-thirds, the style 8.0 mm, bearded dorsally and proximally, 1/3 to 1/2 its length.

Distribution and phenology

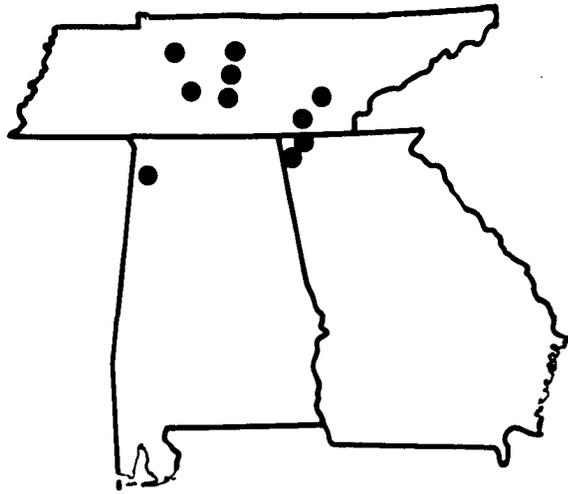
Central Basin of Tennessee, northwestern Georgia and northwestern Alabama. Restricted to glade environments. Initiating anthesis in early May, reaching a peak at the middle of that month and gradually decreasing. Flowering may, however, continue to early August, due to secondary, axillary blooming.

Nomenclature and observations

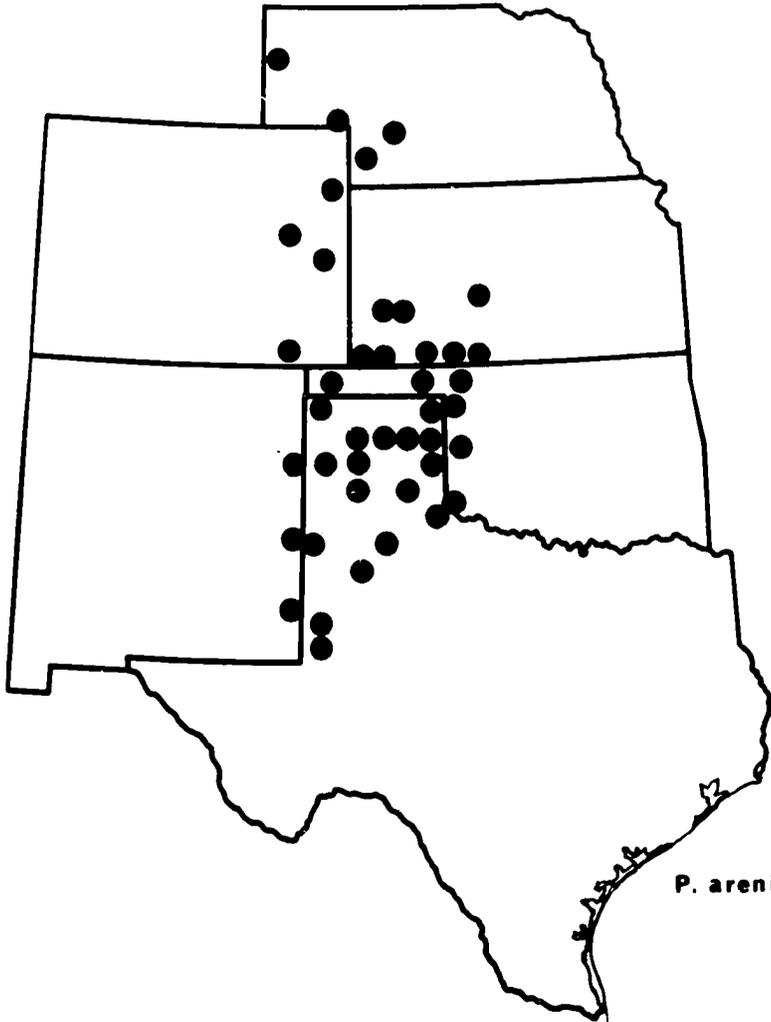
Although Heller, in naming the species in honor of Dr. A. Gattinger, did not single out a specific sheet, he did comment that, "Some of his [Gattinger's] specimens are in Curtiss' North American Plants, no. 565." I have seen five sheets so designated, (SMU, TENN, GA, 2--US). By far the best specimen is at US and I designate it as the lectotype, US 24537.

P. gattingeri is an element of a flora endemic to the Cedar Glades of Central Tennessee and adjacent areas. The glades are a part of the Central or Nashville Basin (Quarterman 1950) and occur where the usual rolling upland pastures and alluvial farm lands are eroded away exposing horizontal layers of Lebanon limestone and Ordovician sediment. These strata are impervious to water and at certain times of the year are submerged. Some drainage is accomplished through small sink holes and vertical fissures which fill with soil allowing growth of clumps or rows of trees or larger shrubs. The strata themselves are often covered with a thin layer of soil varying up to one foot in depth. It is in this substrate than P. gattingeri grows. Quarterman classified P. gattingeri as a "characteristic species" i.e. it was found in over 80% of the glade areas she examined. Nostoc commune Vauch. and Aristida longispica Poir. were the only other two species to be so recognized, but the glades contain numerous other endemics. Quarterman presents two hypotheses to explain the characteristic flora of the glades: 1.) "The occurrence

Fig. 47. Geographical distribution of Petalostemon
gattingeri and P. arenicola



P. gattingeri



P. arenicola

of both wet and dry extremes must limit the number of species capable of living in glade areas" and 2.) "Restriction of certain species to glades is probably also affected by their inability to compete with mesic species in more favorable habitats."

Dolomitic limestone glades also occur in east central Missouri and many of the same species are found on these glades but Petalostemon gattingeri is not among them. I have collected P. purpureum from one such glade in the Missouri Botanical Garden arboretum, Franklin county, Missouri (Wemple 478). This plant appeared no different from the typical prairie form of P. purpureum elsewhere in Missouri.

Under greenhouse culture, the matted growth habit of P. gattingeri remains constant as do all the distinctive floral characters. Progeny grown from field collected seeds were uniform, growing and flowering with no special care beyond that given to other species of Petalostemon.

25. PETALOSTEMON PULCHERRIMUM (Heller) Heller (Figs. 48, 53H)

Petalostemon pulcherrimum (Heller) Heller. Bull. Torr. Bot. Club 26: 593. (1899). Based on Kuhnistera pulcherrima Heller.

Petalostemon virgatum Scheele. Linnaea 21: 461. (1848). (2). Not P. virgatum Nees von Esenbeck. (1840).

Petalostemon violaceum var pubescens Gray. Smith. Contr. Knowledge 3: 46. (1852). Based on Petalostemon virgatum Scheele.

Kunistera pulcherrima Heller. Contrib. Herb. Franklin and Marshall College 1: 50-51. (1895). Based on Petalostemon virgatum Scheele.

Petalostemon pubescens (Gray) Heller. Muhlenbergia 1: 28. (1901). Based on Petalostemon violaceum var. pubescens Gray. Not Petalostemon pubescens A. Nels. (1901).

Dalea stanfieldii (Small) Shinners (in part). Field and Lab. 17: 84. (1949). Based on Petalostemon stanfieldii Small.

Dalea Helleri Shinners. Field and Lab. 21: 165. (1953). Based on Petalostemon virgatum Scheele.

Description

Stems many, usually robust, varying from erect to decumbent, 3.5--7.5 dm in length, usually smooth near the base, becoming striate in upper portions; red "glands" apparent on dried stem, 1 mm in diameter, flush with surface; three vertical ribs below leaf axes not obvious on lower parts of stems but becoming apparent above; glabrate to moderately pubescent, usually more pubescent at apex of peduncle. Stipules subulate-setaceous, 3--5 mm in length. Leaves fascicled, seldom more than three trifoliate leaves in axils; leaflets 3--7, the terminal one to 26 mm long and 3 mm at widest point, elliptical, slightly involute; glandular and ciliate below, non-glandular and glabrous above. Peduncles 4--15 cm long. Inflorescence a columnar, non-expanding spike, 15--35 mm long, 11--14 mm wide. Bracts not precocious, never exceeding calyx lobes even in bud; acumen 0.6--1.2 mm long, subulate, drying black, always shorter than the calyx lobes and usually as

short as the tube itself at anthesis; body, 2.5--3.0 mm long, not markedly expanded distally, pubescence restricted to a transverse belt of appressed cilia immediately below the acumen and a ciliate fringe along the margin toward the rachis, strongly clasping the calyx throughout its length. Calyx tubular, dorso-lateral surfaces flat, ventral surface curved; tube glabrous, white, drying to a pale, thick, parchment-like surface save for two bands of appressed cilia along lateral margins, silvery, drying rufous; entire calyx tissue infiltrated with a gum, which dries to a shiny red, often showing through to the outside as red streaking; tube 3.2--3.9 mm long and 1.9--2.4 mm in diameter; lobes pubescent, especially on margins, incurved and valvate in bud, opening slightly at anthesis, usually flared in fruit, dark green, drying reddish on the outer surface, remaining green on the inner, the ventral lobe 1.0 to 1.6 mm long; extruded red gum lobelets ca. 0.1 mm long scattered along margins. Corolla blue to lavender-purple, the standard suborbicular and slightly lobed, 2.5--2.9 mm wide, 2.7--2.8 mm long, the claw 4.0--4.5 mm; in fresh flowers the claw is parallel to the staminal tube until just below the blade whence it reflexes upward at 90° ; the apical petals oblong, sometimes slightly obovate, 3.1--4.2 mm long, 1.2--1.4 mm wide, the lateral pair with claws offset to one side, in the fresh flower arching up above, and lateral to, the medial pair; claws 1.0--1.4 mm long. Staminal tube exserted beyond the calyx lobes; filaments purple when fresh,

anthers bright orange, exceeding the apical petals, the longitudinal dehiscence lines deep red. Ovary completely glabrous, 1.3--1.7 mm long, 0.8--1.2 mm in diameter; style usually completely glabrous, occasionally slightly ciliate dorsally on the proximal third, inserted slightly below the longitudinal axis of the ovary, never exceeding the exertion of either petals or anthers, pigmented purple distally. Pod developing mostly ventrally and distally, the proximal tissues of the style persisting as a dorsally directed beak.

Distribution and phenology

Restricted to rich, blackland prairies and associated areas in east-central Texas and adjacent counties in southern Oklahoma. Occurrence in western Texas (Hudspeth County) and New Mexico (Socorro County) is documented by only one collection each, possibly representing introductions. Primary flowering time is from mid May to early June.

Nomenclature and observations

Adolf Scheele in "Beitrage zur Flora von Texas" (1848) was the first to apply a name to this species. His description is lucid and concise, clearly setting it apart from P. violaceum (P. purpureum). Unfortunately, his name, P. virgatum, had been pre-empted nine years earlier by Nees von Esenbeck and is now in synonymy under P. occidentale. It is probable that Asa Gray, the next person to deal with the

nomenclature of this taxon did not realize that Scheele's name was a later homonym. Gray's work has been discussed in detail by Heller (1901). The following is but a brief review.

Gray in Plantae Lindheimerianae (1850) stated in a footnote (p. 176):

Petalostemon virgatum, Scheele, in Linnaea, 21, p 461, is plainly the No. 42, Pl. Lind. [of Lindheimer] and No. 137, Pl. Fendl. [of Fendler], viz. a pubescent variety of P. violaceum, perhaps connecting that species with P. decumbens.

I have examined the three sheets comprising Lindheimer 42 (GH) and they are clearly P. pulcherrimum (Scheele's P. virgatum). The single sheet, Fendler 137, is definitely not the same species but rather it is what Gray described -- "a pubescent variety of P. violaceum" -- i.e. P. purpureum. In short, Gray misinterpreted Scheele's concept of P. virgatum, or perhaps as Heller (1895) put it, "...Dr. Gray very much underrated the excellent work of Scheele, refusing, at least for a time, to recognize some very good species which he described."

In Plantae Wrightianae (1852), Gray actually published P. violaceum var. pubescens but further compounded nomenclatural problems by writing (p. 46):

117. Petalostemon violaceum, Michx., var. pubescens (Gray, Pl. Fendl. p 33). P. virgatum, Scheele in Linnaea, 21. p 461. Prairies, Austin, Texas. -- From the Snake Country, in the interior of Oregon, Mr.

Burke sent to Sir Wm. Hooker dwarf specimens of this variety, and from the Black Hills of the Platte both Burke and Gordon have sent others, with densely pubescent leaves and even tomentose stems, which I cannot otherwise distinguish from this species.

This discussion presents two nomenclatural problems. First, Gray's citation back to his preceding publication, Plantae Fendlerianae (1849), is incorrect because there, under No. 137, Gray has: "P. violaceum Michx. Fl. 2. p. 50. t. 37. f. 2: -- a pubescent variety; the calyx very silky-villous. Five miles west of Las Vegas, New Mexico; August." This is not a valid publication of a new variety. Secondly, his use of the Scheele name as a synonym follows that in his Plantae Lindheimerianae discussion, but he cites the Burke and Gordon specimens as representatives of this new taxon. I have examined one of Burke's sheets (NY, unnumbered, Snake River Country) and it fits into the general range of variation of P. purpureum. Even though Gray obviously intended this name for the extremely pubescent forms of P. purpureum, still, according to nomenclatural practice, the name P. violaceum var. pubescens is legally based on the description of P. virgatum Scheele.

Heller published Kuhnistera pulcherrima as a nomen novum in 1895 and based it on P. virgatum Scheele. Following the description he speaks of his finding the plant and recognizing its individuality from other purple flowered species and naming

it a "n. sp.", the designation that occurs on his widely distributed No. 1857 (3-ISC, 2-SMU, 2-US, 1-NY, 1-MO, 1-OKLA).

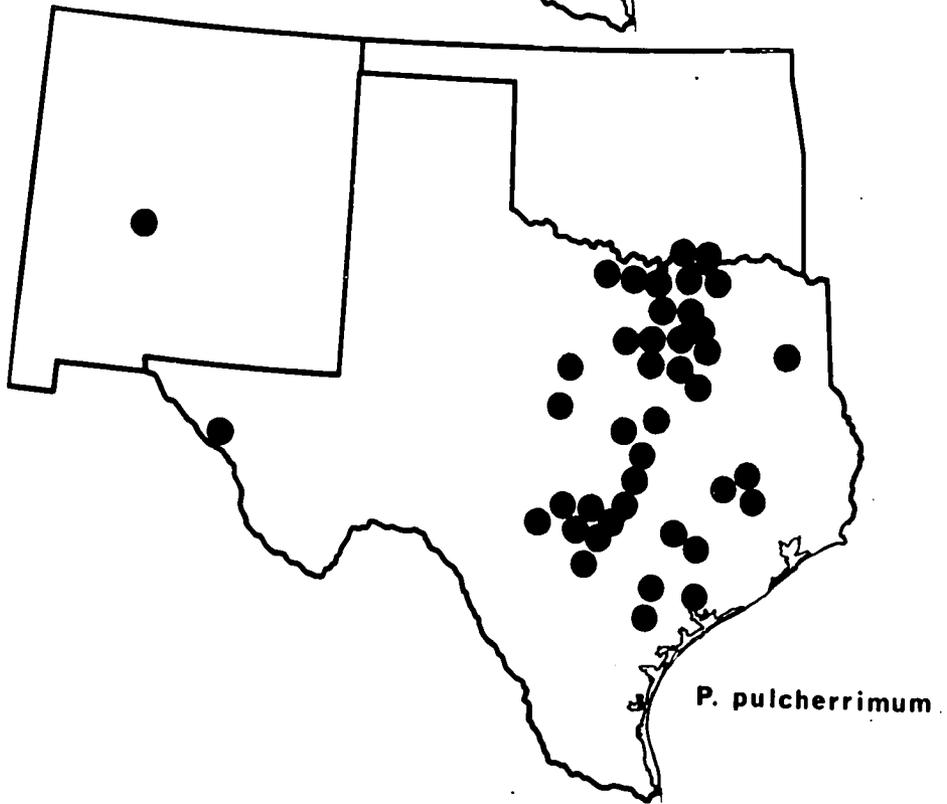
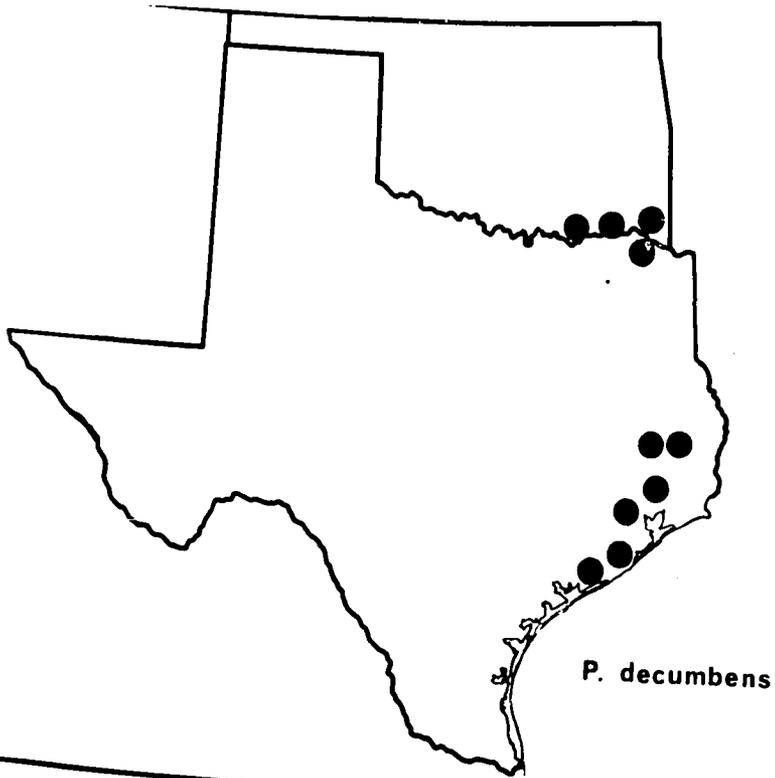
Four years later (1899) Heller transferred K. pulcherrima to Petalostemon along with three other species originally placed in Kuhnistera. In the July, 1901 issue of Muhlenbergia, Heller made a final transfer of his species to P. pubescens (A. Gray) Heller, listing P. violaceum var. pubescens A. Gray., P. virgatum Scheele, K. pulcherrima Heller and P. pulcherrimum (Heller) Heller, as synonyms. He concluded with this sentence:

This beautiful species has been burdened with much synonymy mainly by the writer, who may perhaps be pardoned for not earlier understanding the true place of publication of the first available name, when viewed in the light of the preceding article.

Unfortunately Heller's publication appeared one month after the publication by Aven Nelson of P. pubescens (Bot. Gaz. 31: 395. 1901, June) and so it too, is a later homonym.

Petalostemon pulcherrimum is readily recognized by four characteristics: 1.) long peduncles, 2.) a long tubular calyx with short lobes, 3.) a glabrous calyx tube except for the ciliate bands on the lateral margins, and 4.) short bracts. The growth pattern is variable and ranges from decumbent to erect. This variation was first thought to be due to hybridization with P. decumbens but analysis shows decumbent material clearly to be P. pulcherrimum. Hybridization with P. purpureum has been previously discussed.

Fig. 48. Geographical distribution of Petalostemon
decumbens and P. pulcherrimum



26. *PETALOSTEMON DECUMBENS* Nutt. (Fig. 48, 53B)

Petalostemon decumbens Nutt. Jour. Acad. Nat. Sci. Phil. 7: 93. (1834). Type in NY. (1)(2).

Kuhnistera decumbens (Nutt.) Kuntze. Rev. Gen. 1: 192. (1891). Based on *Petalostemon decumbens* Nutt.

Description

Stems many, arising from a prominent caudex, usually decumbent and apically ascending, occasionally erect, partially supported by adjacent vegetation, 2--5 dm long, glabrous and smooth at base becoming slightly pubescent and striate above. Stipules 4--6 mm long, subulate, never thicker than 0.5 mm at base. Leaves fascicled with seldom more than two trifoliate leaves in axes of major leaves. Leaflets 7--9, elliptical, 17--25 mm long, 3.0--4.6 mm wide, rarely involute, the tip subulate; rachis extended beyond distal pair of leaflets 0.5--3.5 mm. Peduncle short, often lacking, never over 3 cm long. Inflorescence a columnar, non-expanding spike, 14--36 mm long, 13--16 mm wide. Bracts long-acuminate, exceeding the calyx in bud and at anthesis; body 2.8--3.5 mm long, neither strongly clasping nor sharply narrowing at base, lateral margin often scarious; entire bract glabrous save for a small triangular area of appressed cilia at widest part; body gradually tapering distally to a narrowly lanceolate acumen, 4--7 mm long, often reflexing abaxially. Calyx tubular, deltoid in cross-section with a rounded base; tube generally glabrous except for two bands of appressed cilia along lateral

margins which traverse the entire length of the calyx and general appressed pubescence between the bands on the proximal 1/3 of the tube; tube 3.6--4.3 mm long, 2.2--2.6 mm in diameter; lobes pubescent, incurved, valvate in bud, barely opening at anthesis, ventral lobe 2.0--2.7 mm long. Corolla blue to blue-purple; standard blade oval-deltoid, strongly concave, not basally lobed, 2.3--2.7 mm wide at base, 2.4--3.0 mm long, the claw 5--6 mm long; apical petals oblong, often slightly lobed at the base, 3.5--4.0 mm long, 1.2--1.5 mm wide, the claw 1.0--1.4 mm. Staminal tube not exerted beyond the calyx lobes; filaments tinged blue-purple, exceeding petals; anthers orange, the dehiscence line bright red. Ovary glabrous, 1.5--1.7 mm long, 0.9--1.1 mm in diameter; style usually glabrous, occasionally slightly ciliate, roseate at tip, exerted slightly beyond anthers soon after anthesis. Pod developing by enlargement of the ventral-distal portions of the ovary, the style base persisting as a beak on the legume.

Distribution and phenology

Distribution bicentric. Northern populations found in counties of southeastern Oklahoma and adjacent counties in northeastern Texas. Southern population center is in southeastern Texas. Restricted to calcareous soils with underlying horizontal limestone strata -- glade conditions. Flowering from mid April to early June, reaching a maximum in early May.

Nomenclature and observations

Nuttall's definitive description (1834) concludes, "On the plains of the Red River, Common, Flowering in June." The specimen at Philadelphia is labeled in Nuttall's hand, "Arkansas." Adjacent to the name P. decumbens is an asterisk, Nuttall's designation for a new species. The asterisk, however, is in pencil, not ink, as is the rest of the label. A specimen in the New York type collection is labeled in Nuttall's handwriting with the location, "Red River." It too has an asterisk but in ink of the same type as the rest of the label. It is a better specimen than the one at PH which has lost most of its leaves. A third Nuttall specimen at Cambridge labeled, "Arkansas Red River" lacks an asterisk. Presumably these three sheets were in Nuttall's possession when he prepared his description and were subsequently distributed. It seems best to choose the specimen at NY to be the lectotype on the basis of, 1.) the distinguishing asterisk matching the rest of the label, 2.) the exact locality as in the description and 3.) the quality of the specimen.

The distributional pattern of this species is unique, the two disjunct areas being separated by over 200 miles. The soil types, however, are very much alike, both calcareous in nature. The southeastern counties of Oklahoma possess other restricted species e.g. Leavenworthia aurea Nutt. and Lesquerella angustifolia (Nutt.) Wats. (Cruciferae). Rollins (1956, 1963) attributes the limited range of L. aurea to the

thin soil with underlying horizontal limestone strata -- a glade condition. This species, also bicentric in its distribution, has been collected in San Augustine county, Texas -- within 50 miles of the southern distribution of P. decumbens. It is probable that the habitat dictates the distribution of L. aurea and P. decumbens in the same manner.

Hybridization between P. decumbens and P. purpureum in southeastern Oklahoma has already been discussed.

27. PETALOSTEMON PURPUREUM (Vent.) Rydb. (Figs. 49, 53C)

Petalostemon purpureum (Vent.) Rydb. Mem. N. Y. Bot. Gard. 1: 238. (1900). Based on Dalea purpurea Vent.

Dalea purpurea Vent. Desc. Pl. Cels. pl. 40. (1800). Type in G. (1)(2).

Dalea violacea Michx. ex Willd. Sp. Pl. III 1337. (1802). Original material in B. (1)(2).

Petalostemon violaceum Michx. Fl. Bor. Am. 2: 50. (1803). Original material in P. (1)(2).

Psoralea purpurea Poir. in Lam. Encycl. Meth. 5: 694. (1804). Based on Dalea purpurea Vent.

Petalostemon violaceum var. pubescens Gray. (Quoad material in part non citation) Smith. Contr. Knowledge 3: 46. (1852). Based on Petalostemon virgatum Scheele.

Kuhnistera purpurea (Vent.) MacMillan. Metas. Minn. Vall. 329. (1892). Based on Dalea purpurea Vent.

Petalostemon molle Rydb. Mem. N. Y. Bot. Gard. 1: 238. (1900). Original material at NY. (1)(2).

Petalostemon pubescens A. Nels. Bot. Gaz. 31: 395-396. (1901). Holotype in RM. (1)(2). Not P. pubescens (Gray) Heller (1901) which is P. pulcherrimum.

Petalostemon purpureus mollis (Rydb.) A. Nels. New Man. Bot. Cent. Rocky Mts. Coulter and Nels. 299. (1909). Based on Petalostemon mollis Rydb.

Petalostemum purpureum f. arenarium Gates. Torreyia 2: 125-128. (1911). Holotype at F. (1)(2).

Petalostemon standleyanus Rydb. Fl. N. Am. 24: 131. (1919-1920). Type in US. (1)(2).

Petalostemum purpureum f. pubescens (Gray) Fassett. (Quoad concept non basionym) Rhodora 38: 96. (1936). Based in part on P. violaceum var. pubescens Gray.

Petalostemum purpureum f. albiflorum Horr. & McGreg. Trans. Kan. Acad. Sci. 55: 175. (1952). Holotype at KANU. (1)(2).

Petalostemon purpureum pubescens (A. Nels.) Harr. Manual Pl. Colorado 319. (1954). Based on P. pubescens A. Nels.

Petalostemon purpureum var. pubescens (Gray) Boiv. (Quoad concept non basionym) Nat. Canad. 87: 43. (1960). Based on P. violaceum var. pubescens Gray.

Description

Root black with multiple stems arising from a prominent caudex. Stems usually erect, 2--8 dm tall, \pm pubescent, generally branching near the top, striate with three prominent vertical ribs immediately below each leaf. Stipules subulate, glabrous, reaching a maximum of 8 mm, drying dark, often fugacious. Leaves prominently fascicled, each leaf bearing at least two trifoliate leaves in its axil and often an entire compressed branch system; nodes usually close together giving the plant a dense, leafy appearance. Leaf rachis extending to 3 cm bearing 3--5 (7) linear, strongly involute leaflets, 6--20 mm long and 0.8--2.0 mm wide; the proximal pair inserted in

the distal 1/3 of the rachis; petiolules usually ciliate even in otherwise glabrous material; lower surface, when dried, dotted with small, dark glands and often pubescent, the upper surface nonglandular and glabrous. Peduncle short, usually less than 1/4 the entire height of stem, usually more pubescent above than below. Inflorescence a compressed, non-expanding, columnar spike, usually at least three times as long as wide, 30--70 mm long, 10--15 mm in diameter. Bracts persistent and precocious, exceeding the calyx in bud but usually shorter than the lobes at anthesis; acumen dark, subulate, often pubescent; bract body expanded distally and covered with a characteristic transverse band of appressed cilia, glabrous and contracted proximally, tightly clasping the calyx base, the calyx \pm tubular, 2.5--4.0 mm long, not conspicuously ribbed, usually entirely covered with appressed, silvery pubescence; the three lower lobes often incurved toward the calyx axis, the ventro-lateral pair often overlapping the dorso-lateral lobes; the ventral lobe 1--2 mm long, all lobes green tipped, sometimes becoming bald but the margin always ciliate. Corolla varying from pale purple to a deep red-purple, standard globose and concave, often with prominent auricles flanking the claw, the blade 1.4--2.4 mm in diameter, the claw 3.4--4.0 mm; apical petals spreading at anthesis, the blades oblong, 2.5--3.0 mm long, 0.8--1.0 (1.5) mm wide. Staminal tube equalling or exceeding the calyx lobes; filaments tinged purple with the anthers exerted beyond the petals; the

pollen orange. Ovary spherical or slightly elliptical, bearded on the distal-ventral one-half, the dorsal surface bald; style arising on the longitudinal axis of the ovary, bearded proximally and dorsally $1/3$ to $1/2$ its length, usually exerted beyond the anthers soon after anthesis.

Distribution and phenology

Throughout the short grass plains and prairies of southern Canada and the United States. North to south: from southern Alberta, Saskatchewan and Manitoba, to eastern New Mexico, central Oklahoma and Arkansas; scattered in isolated colonies in Louisiana, Mississippi and Alabama; in Texas along the Red River Valley and rarely into the Black Belt Prairie region. East to west: from central Indiana to Montana, central Wyoming and central Colorado.

Anthesis: northwest, mid June to early August; southwest, late May to late July; northeast, late May to mid August; southeast, mid May to early June.

Nomenclature

Petalostemon purpureum was observed and collected by Michaux in Illinois and introduced into Europe in 1794. Verification of this date is given by Ventenat (1800) and by a label affixed to one sheet of Willdenow's original material at B: "ab Ann. 1794." The Ventenat name appeared in, Description

des plantes nouvelles et peu connues, cultivées dans le jardin de S. M. Cels, and he made good use of the unusual opportunity of studying an American plant growing on European soil. His description and accompanying drawing are superior. His collection is currently housed in the Herbarium Delessert, Conservatoire et Jardin Botaniques, Geneva. In the collection are two specimens, one clearly marked "Dalea N. Sp. purpurea Hort. Cels," the other, "Dalea purpurea Vent. H. C. -- violacea W. Petalostemum violaceum Michx." I take the former to be the typus.

The Willdenow collection at Berlin-Dahlem possesses three sheets referable to Willdenow's Dalea violacea which appeared in Volume III of Species Plantarum, the name attributed to Michaux. Michaux' original material is in Paris. Dr. A. Lourteig kindly sent me two specimens representative of the material in the Herbarium Richard. They are both of one species but differ in degree of pubescence, a common variation seen throughout the range of P. purpureum.

The problems involved in typification of Petalostemon violaceum var. pubescens Gray has been discussed under P. pulcherrimum. In summary, Gray's variety is P. pulcherrimum as to citation, but his material included both P. purpureum (Fendler No. 137) and P. pulcherrimum (Lindheimer No. 42). Both P. purpureum f. pubescens (Gray) Fassett and P. purpureum var. pubescens (Gray) Boiv. are based on the Fendler specimen. Petalostemon mollis Rydb. is based on four collections.

I have seen duplicates of Canby, Snowy Mts., 1882 from Montana at NY. The specimens are very pubescent plants, practically lacking a peduncle, possessing leaflets only slightly involute making them seem quite wide in comparison to other members of the species. In addition, the apical petals are uncommonly wide and represent the measurements in parentheses in the descriptions of these structures. A similar phenotype also occurs in southeastern Colorado but possesses a prostrate-assurgent habit, and has received the name P. pubescens A. Nels. The holotype for the Nelson name is at RM and an isotype at NO. Both of these forms of P. purpureum are apparently rare. I have seen only six sheets including the types which fit the description of P. pubescens and only the two sheets referable to the Rydberg "species."

Rydberg in his portion of Flora of North America (1919-1920) created P. standleyanus for the moderately pubescent purple species found in New Mexico. I have studied the holotype and it falls within my delimitation of P. purpureum. It most closely resembles the more pubescent forms found in Colorado and Wyoming, particularly regarding petal size and calyx length.

Observations

Petalostemon purpureum is variable with respect to amount of pubescence. Truly glabrous individuals are rare but they are found throughout the entire range of the species. Most

specimens are pubescent at least on the petiolules and the lower surface of the leaflets. The greatest number of extremely pubescent plants is found in the northwestern part of the range and Colorado to New Mexico. However, glabrate or completely glabrous specimens are not lacking in these areas. For example, A. Hayden, July 1929, Ft. Collins, foothills, is represented by two sheets (ISC 101400, 101735). One specimen is moderately pubescent, the other is glabrous. Close examination of both indicates, however, that in all other respects, the two entities are identical. Collections from Montana indicate that the specimens from higher elevations are generally low in stature but a wide range of pubescence is exhibited. Pubescence variations in the Canadian specimens parallel those found in the United States. Towards the west, there is an increase of pubescent forms, yet in the same areas where the "mollis" forms are found, there are glabrate ones. A collection from the extreme northwestern part of the range in Alberta is almost glabrous [G. H. Turner, 17 (NY)].

Disposition of extremely pubescent, broad-leafed variants -- P. pubescens A. Nels. and P. mollis Rydb. is difficult. From my herbarium study of these taxa, they seem more deserving of elevated rank than any other variation in the extensive P. purpureum complex. Harrington, in his comparatively recent "Manual of the Plants of Colorado" (1954), relegates P. pubescens A. Nels. to the subspecific level and comments, "Intergrades with the typical form." -- a comment presumably

based on field experience. Lacking personal field experience in this region, I am adopting a conservative approach and considering the two as phenotypic extremes of an inherent polymorphism in this widespread species. The names are relegated to synonymy.

A cinereous or silvery-pubescent condition of the calyx and rachis is characteristic of P. purpureum. The rachis pubescence is usually carried to slightly below the inflorescence. The calyx tube is always invested with appressed, to slightly spreading pubescence but "balding" of the lobes occurs sporadically throughout the range. It is most common in specimens from Arkansas and Missouri, especially those collected in the vicinity of Kansas City but it is also found as far north as Wisconsin. This variation accounts for the reports of the occurrence of P. pulcherrimum north of Texas and southern Oklahoma. My studies indicate that this is no evidence for introgression with any other species. Calyx pubescence variation does not seem to be of sufficient significance to justify nomenclatural recognition.

The growth habit of certain southeastern specimens of P. purpureum is different from that in other parts of the range. Several collections from Arkansas, Louisiana and Alabama are decumbent or prostrate. With this is coupled the possession of extremely small leaves and small flower spikes. In all other respects, i.e. floral characters, these plants can not be excluded from P. purpureum. They are generally limited to

specific habitats, for example, "glades" or chalky-marl soils. The holotype of P. purpureum f. arenarium Gates, a sand dwelling "ecotype" from Illinois possesses many of the same characteristics. Perhaps there has been phenotypic convergence between these widely separated populations since both grow in rather unusual environments for the species.

The normal leaflet number for P. purpureum is 3--5. In the five leaflet form, the proximal pair of leaflets are invariably inserted on the distal one third of the rachis. Specimens possessing seven leaflets are rare but scattered throughout the range of the species from such widely disparate locations as Lucas Co., Iowa; El Paso Co., Colorado; and, Blaine Co., Oklahoma. Of the over 800 specimens of Petalostemon purpureum I have examined, only ten were found to have seven leaflets.

Hybridization between P. pulcherrimum and P. decumbens and P. purpureum has been discussed previously.

28. PETALOSTEMON TENUE (Coult.) Heller (Figs. 46, 53D)

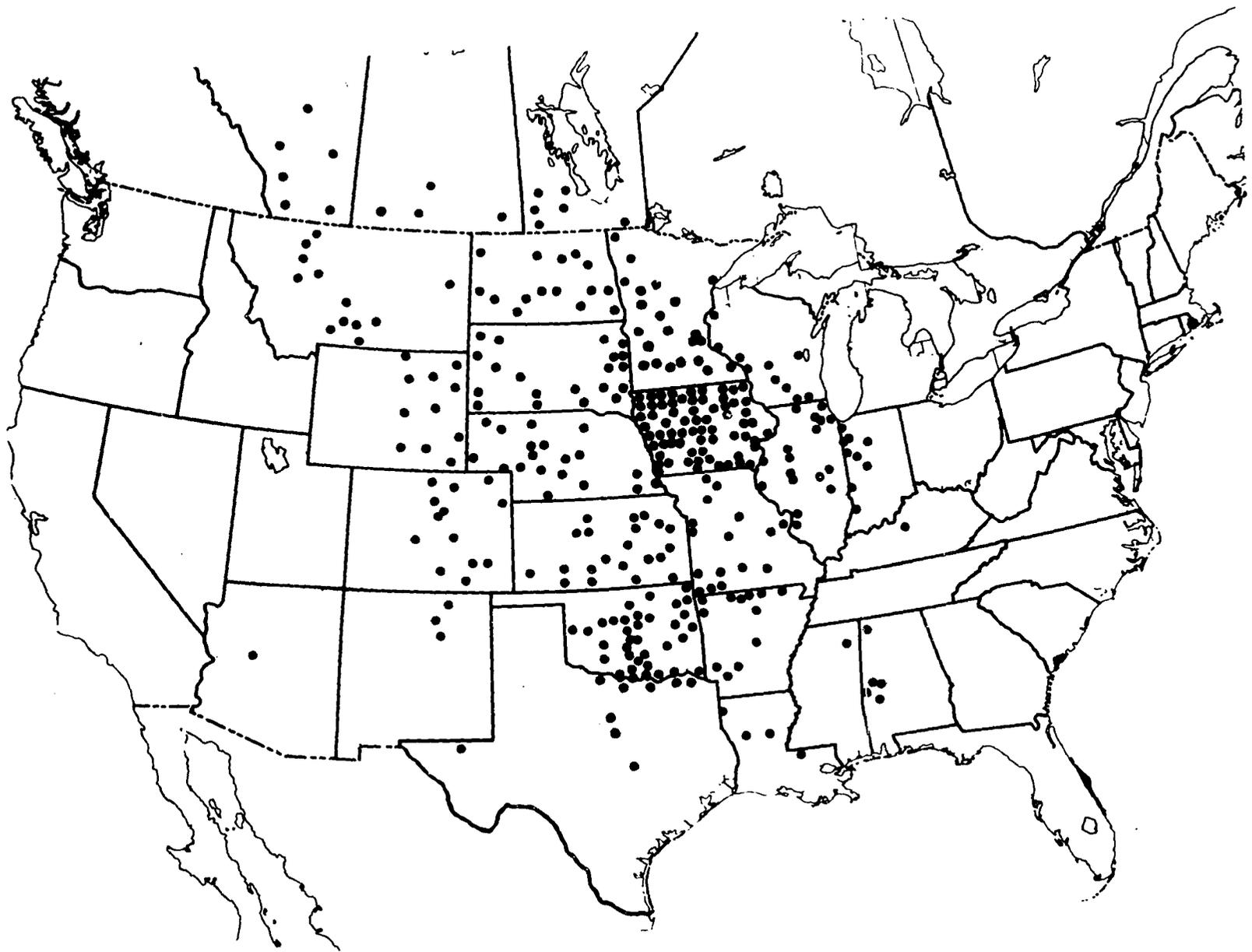
Petalostemon tenue (Coult.) Heller. Bull. Torr. Bot. Club 26: 593. (1899). Based on Petalostemon violaceus var. tenuis Coult.

Petalostemon violaceus var. tenuis Coult. Contr. U. S. Nat. Herb. 1: 34. (1890). Type in US. (1)(2).

Kuhnistera tenuis (Coult.) Heller. Bull. Torr. Bot. Club 23: 124-125. (1896). Based on Petalostemon violaceus var. tenuis Coult.

Petalostemon stanfieldii Small. Fl. S. E. U. S. 631. (1903). Type in NY. (1)(2).

Fig. 49. Geographical range of Petalostemon purpureum



Petalostemum grothii Macbr. Contrib. Gray Herb. N. E. 49: 49. (1917). Type in GH. (1)(2).

Dalea tenuis (Coult.) Shinnars. Field and Lab. 17: 84. (1949). Based on Petalostemon violaceus var. tenuis Coult.

Dalea stanfieldii (Small) Shinnars. Field and Lab. 17: 84-85. (1949). in part. Based on Petalostemon stanfieldii Small.

Dalea purpurea var. tenuis (Coult.) Shinnars. Field and Lab. 21: 165. (1953). Based on Petalostemon violaceus var. tenuis Coult.

Description

Stems many, branching above, 2.0--5.5 dm tall, pale, moderately striate with three prominent vertical ribs below the nodes, usually glabrous but occasionally evenly glabrate; center stems erect, peripheral ones often almost parallel with the ground. Stipules setaceous, dark, to 4.5 mm in length. Leaves fascicled; nodes close, producing a leafy appearance; leaflets 3--5 (7), the proximal pair inserted in the distal one-third of the rachis, prominently gland-dotted below and often moderately ciliate. Peduncles long, 3--18 cm, from 1/5 to 1/2 total length of the stem, usually glabrous, rarely pubescent immediately below the spike. Inflorescence a compact, non-expanding spike, often conical in bud, becoming columnar in fruit, 12--44 mm long, 7--11 mm in diameter; rachis pubescent; bracts precocious but at anthesis equal to or shorter than the lobes, body 2.4 mm long, the dark acumen 1.3--2.2 mm long, a slight pubescent band at broadest part of bract body

(about in the middle of the whole bract), usually with a ridge of cilia along the back toward the rachis; from the transverse belt of cilia proximally, the margin of bract is fringed; base of bract neither clasping the calyx nor sharply tapered; entire bract persistent even after mature fruit falls from rachis. Calyx tube campanulate, 2.0--3.5 mm long and 2.0--2.9 mm in diameter, invested with retrorse hairs, all pointed toward base of calyx; pubescence most strongly developed on the lateral ribs; lobes often bald but with ciliate margins; dorso-lateral lobes large, deltoid, arising from flat surfaces of the tube; ventro-lateral and ventral lobes lanceolate, arising from hemispherically curved surface of the tube; ventral lobe 1--2 mm long; in bud, lobes incurved and valvate, scarcely opening at anthesis. Corolla purple; standard auricled, not emarginate at apex, 2.1 mm long, 2.2 mm wide, broadly deltoid; apical petals 1.1--1.5 mm wide and 2.3--3.6 mm long, auricled at base, the claw 0.5 mm long. Stamens bright orange, extended as far as the petal tips. Ovary glabrous save for a few cilia distally and dorsally in some specimens, never bearded ventrally, 1.1--1.9 mm long, 0.6--1.0 mm in diameter, usually less than twice as long as high; style inserted on the longitudinal ovary axis, bearded dorsally for one-half its proximal length. Legume ventral surface developing more than dorsal so that in fruit the beak (remnant of style) is offset dorsally.

Distribution and phenology

Limited to the eastern Edwards Plateau in Texas and adjacent areas to the east; north and south from Wise to Bexar county, east and west from Coryell to Irion county, Texas. Always found in rocky, limestone soil. Common along roadsides. Anthesis beginning in early May, reaching a peak in early June, ceasing by early July.

Nomenclature and observations

The primary unifying characteristics of this species are its distribution and habitat preference, and the possession of retrorse pubescence on the calyx tube. The latter character is unique in the genus.

This taxon has been known as P. stanfieldii Small, but it must yield priority to the earlier P. tenue (Coult.) Heller. Both types fall within the circumscription of this species as I understand it. The type specimen of P. violaceum var. tenuis Coult. is in US, No. 23346, Santa Anna, Coleman Co., Texas. G. C. Nealley, 1889. A photograph is also at NY. The Coulter interpretation is not without flaws. Following a brief description he states:

Santa Anna (Coleman county). Apparently the form referred to in Pl. Fendl. under No. 138. The species is an exceedingly variable one, but the above variety is so distinct that it seems to deserve a name and description.

I have seen Fendler No. 138 (MO) and it is clearly a P. tenuifolium with expanding spikes and spreading pubescence.

In the transfer of Coulter's variety to species level, Heller (1896) makes this pertinent comment:

This is a very good species, quite distinct from the Petalostemon violaceus, which has been made a dumping ground of various red-flowered species which are not at all related to it. This species is much more closely related to Reverchoni than to purpurea.

With this I concur.

In his description of Petalostemon stanfieldii, Small does not name a type, merely listing the distribution as, "On plains or prairies, Texas." There is a specimen in the J. K. Small collection at NY labeled, "Type," in what I take to be Small's handwriting. It was collected by S. W. Stanfield, Summer 1896 at San Marcos and vicinity." Rydberg (1919-1920) apparently accepted this specimen as the type because he indicates, "Type locality: San Marcos, Texas."

The type specimen of Petalostemon grothii is at GH. I have also studied an isotype from US, No. 717748. Although collected in fruit, it is without doubt P. tenue as herein described. MacBride comments on the persistence of the bracts (visible only in fruit) which is unique among purple species. The collecting site is within the range of P. tenue, also.

Shinners (1949) transferred both P. tenue and P. stanfieldii to Dalea. Under the latter name he included P.

pulcherrimum (Heller) Heller and its synonymy. In 1953 he removed P. pulcherrimum and renamed it Dalea helleri Shinnery. In the same paper, passing almost unnoticed in the body of the paragraph, is a retraction of his acceptance of Dalea tenuis (Coulter) Shinnery, relegating it to a variety of Dalea purpurea. He based the combination on the type specimen at US, which he saw. He states:

Considerably resembling D. helleri is D. purpurea Vent. var. tenuis (Coulter) Shinnery, comb. nov. ..., which has the calyx tube pubescent throughout with more or less appressed hairs instead of loose or spreading ones as in var. purpurea. D. purpurea var. tenuis is known from Coleman and Taylor counties;

P. tenue is limited in its distribution to the eastern Edwards Plateau, its escarpment and outliers. It possesses many characteristics in common with P. arenicola, but differs sharply from that species in its distribution, habit preference and the unique characteristic of retrorse calyx pubescence. This can best be observed in a dried specimen because when fresh, the trichomes are silvery-transparent and difficult to see. It is particularly apparent at the base of the calyx.

Two other species have ranges which overlap that of P. tenue. They are P. pulcherrimum and P. purpureum. P. tenue can usually be differentiated visually on the basis of size, being smaller than the other two species both in stature and

spike size. It also has a habitat preference decidedly different from that of P. pulcherrimum in that it is found in rocky limestone areas whereas P. pulcherrimum is characteristically found in black calcareous soils in this region of Texas.

29. PETALOSTEMON ARENICOLA Wemple (Figs. 47, 50, 53I, 54D)

Petalostemon arenicola Wemple sp. nov.

P. tenuifolium authors pro parte

P. purpureum authors pro parte

Description

Petalostemon arenicola Wemple, sp. nov. Caules e basi (raro superne) ramosi glabri vel glabrati 2--4 (5) dm alti striati. Stipulae subulatae fragiles usque 5 mm longae. Folia fasciculata; foliola 3--5 (7) linearia arcte involuta. Pedunculi caules $1/5$ -- $1/2$ aequantes; spicae compactae non producentes 2--5 cm longae 6--9 mm latae. Bractee non amplexicaules nec basi constrictae, cum margine apicali ciliato et cum vitta pubescente prominente transversa in parte expansa; acumen atratum sub anthesi calycis lobis brevius. Calycis tubus campanulatus 2.0--2.9 mm longus, lobi 1.0--1.5 mm longi cum pilis appressis raro demum glabrati. Corolla purpurea. Ovarii apex et venter barbati; stylus dorso barbatus per mediam proximam.

Typus, ISC (Wemple 319).

Plants lacking a prominent caudex; tap root long, pale yellow, 2--4 (5) dm tall, spreading, glabrous or glabrate, striate, prominently 3-ribbed below nodes; branching from the base, seldom above. Stipules subulate, drying dark brown, fragile, to 5 mm in length. Leaves fascicled, primary leaves bearing at least two axillary trifoliate leaves; leaflets 3--5 (7) all inserted in the distal 1/3 of the rachis, linear, strongly involute. Peduncles usually long, 1/5--1/2 the stem length, glabrous. Inflorescence a compact, non-expanding spike 20--500 mm long, 6--9 mm wide; bracts precocious, exceeding the calyx lobes in bud, shorter than lobes in flower; bract body 2.2--2.8 mm long at anthesis, not constricted toward base nor strongly clasping calyx; bearing an appressed, transverse belt of cilia below the dark, brown-black base of the acumen, a ridge of pubescence often extending proximally down the back of the bract; distal edge of the bract fringed-ciliate, cilia often extending out onto the acumen; acumen 0.7--1.4 mm long, drying black-brown. Calyx campanulate, 2.0--2.9 mm in length, 2.1--2.7 mm in diameter at mouth, bearing appressed, anteriorly directed, evenly distributed pubescence; dorso-lateral lobes deltoid and straight, the ventro-lateral and ventral lobes subulate and incurved; ventral lobe 1.0--1.5 mm long, villous-ciliate, seldom balding. Corolla purple, widely opened at anthesis; standard blade 2.2--2.8 mm

across at widest point, 1.8--2.0 mm long, strongly auricled, claw 2.2--2.6 mm long; apical petals oblong, 2.4--3.2 mm long, 1.2--1.6 mm wide, the claws 0.7--1.1 mm. Filaments usually exceeding petals in length, anthers yellow-orange; pollen a bright yellow. Ovary bearded ventrally on distal 1/2, more than twice as long as its diameter (1.2--1.5 mm long, 0.5--0.7 mm in diameter); style arising from above the longitudinal axis of ovary, bearded dorsally on the proximal end to 1/2 its length.

Distribution and phenology

Southwestern Nebraska, eastern Colorado, southwestern Kansas, the panhandles of Oklahoma and Texas and eastern New Mexico. Limited to deep sands of the Llano Estacado, on dunes, blowouts and riverbottoms. Flowering in early July in the northernmost part of the range, early June to early July for the southern part. Texas collections of flowers at anthesis have been made as early as May 1, and as late as August 31. The majority of the collections, however, are as previously stated. The exceptions are probably caused by droughts or early rains typical of the unpredictable rainfall in north Texas.

Discussion

This new species is distinctive both in appearance and in habitat preference from the other purple species of Petaloste-

mon growing in the south central United States. Throughout its range, which is almost precisely the geological delimitation of the Llano Estacado (Fenneman 1938), it is found only in the stream beds, which dissect this massive limestone plateau and stream-associated dunes and blowouts. My field studies indicate that it is never found on the caprock nor partially down canyon walls but only in the sand of the river bottoms. In the southern part of its range it is geographically sympatric with P. tenuifolium. Ecologically the two are quite isolated, however, because the latter species is restricted to the caprock, penetrating only part of the way down the valley walls.

The overlapping distribution, and morphological similarity of P. arenicola and P. tenuifolium has resulted in previous confusion; however, the two are distinguishable morphologically as well as ecologically. The typical P. tenuifolium pubescence pattern (the stem base and the apex of the peduncle pubescent) is never found in P. arenicola. The apex of the peduncle is almost always glabrous in the latter species. One of the easiest field recognition features differentiating the two species is that of rachis elongation. As the spike matures, following anthesis, in P. tenuifolium, it elongates, often becoming sinuous. That of P. arenicola never elongates following anthesis. Accompanying spike elongation in P. tenuifolium is loss of the bracts, whereas, the bracts are retained in P. arenicola. The bracts of the latter species

are never pubescent over their entire surface, nor are they as wide as those of P. tenuifolium; additionally, they are ciliate along the distal margin. The two species differ to some degree in calyx pubescence. This feature is a difficult key character, but P. tenuifolium has a more spreading calyx pubescence while that of P. arenicola is more appressed. The ovary at anthesis is linear in P. tenuifolium often being three times as long as the diameter, while in P. arenicola it is usually about twice as the diameter. The style is axial in P. tenuifolium but decidedly above the longitudinal axis of the ovary in P. arenicola.

Material of P. arenicola has also previously been referred to P. purpureum. The two taxa are quite distinct even though their geographical ranges slightly overlap. The simplest, yet perhaps the most effective characteristic to separate the two species is spike width -- the width of a spike at anthesis or shortly thereafter, calyx lobe to calyx lobe. P. arenicola has spikes narrower than 10 mm while P. purpureum has spikes wider than 10 mm. It was this differentiation that Turner (1959) utilized to exclude P. purpureum from the panhandle of Texas. Concomitantly, he broadly defined P. tenuifolium to include P. arenicola. P. arenicola seldom exceeds 3.5 dm in stem length, while P. purpureum is taller; in addition, the stems of the latter species are usually branched above resulting in numerous spikes from each major stem, while branching is uncommon in P. arenicola. P. purpureum possesses relatively

short peduncles while P. arenicola has longer peduncles, usually 1/4 the length of the stems. The peduncle apex is glabrous in P. arenicola, while almost always pubescent in P. purpureum. Bract pubescence differs between the two species in that the ciliation often extends rearward of the transverse appressed belt in P. arenicola while the entire proximal area of the bract is glabrous in P. purpureum. In addition, the expanded, distal end of the P. arenicola bract is ciliate giving it a "fringed" appearance. Lastly, the ovary instead of being almost spherical with the style extending from the center of the ovary as in P. purpureum, is elliptical in P. arenicola -- at least twice as long as its diameter with the style protruding from the dorsal surface, not the center.

Another species that could be confused with P. arenicola is P. tenue. The two are separated in range by almost 100 miles but are similar in stature and gross appearance. They are readily distinguished by calyx pubescence. On P. tenue the pubescence is always retrorse, that is, pointing rearward toward the axis of the rachis. In P. arenicola the pubescence is oriented in the typical manner, pointing away from the axis of the rachis. A further difference is the glabrous or slightly ciliate ovary of P. tenue while in P. arenicola, the ovary is bearded distal-ventrally.

The differentiatinal characteristics of P. arenicola and the other purple species discussed above are summarized in Table 6.

Greenhouse hybridization experiments indicate that P. arenicola and P. tenuifolium are freely compatible. In fact, in attempted crosses, seed set was unusually high and the hybrids themselves while intermediate in all characteristics were fully fertile. Why do the two species not hybridize in nature? They are seldom separated by more than 1/2 mile, one on the valley floor, the other on the mesa, yet I have seen no hybrids in the field or sheets of any putative hybrids in the herbarium. It is possible that the pollinators of the two are different or that the pollinators are localized, either remaining in the valleys or on the mesas. Another possibility is that the hybrids, while growing vigorously in the greenhouse are less well adapted to the available habitats than the parents in nature, and their survival is limited.

Table 6. Character comparisons between P. arenicola, P. tenuifolium, P. purpureum and P. tenue

Character	<u>P. arenicola</u>	<u>P. tenuifolium</u>	<u>P. purpureum</u>	<u>P. tenue</u>
Plant height	< 3.5 dm	< 3.5 dm	> 3.5 dm	< 3.5 dm
Branching	below	below	above	below
Vegetative pubescence	glabrous-glabrate	dense below & above	glabrate to pubescent	glabrous-glabrate
Peduncle length	usually long	long	short	long
Spike width	< 1 cm	< 1 cm	> 1 cm	< 1 cm
Spike elongation	none	much	none	none
Bract pubescence	transverse belt + back rib. Ant. ciliate fringe	uniform	transverse belt only	transverse belt + back rib. Ant. ciliate fringe
Calyx pubescence	appressed antorse uniform	spreading antorse uniform	appressed antorse uniform	appressed retrorse "balding"
Ovary shape	2 x long as high	3 x long as high	1-1½ x long as high	1-1½ x long as high
Ovary pubescence	bearded	bearded	bearded	glabrous

Fig. 50. Type specimen of Petalostemon arenicola Wemple.
Deposited in ISC



241074

HERBARIUM OF IOWA STATE UNIVERSITY

Petalostemon americanus

5.5 miles south of ... east side of ...

Long, yellowish ... soft, stabilized sand ...

Kearney Co., Iowa

Don K. Sample 319

Fig. 51. Floral parts and seeds of members of section Candidi (A--C) and Carnei (D).

Seeds and ovary drawings x15, other drawings x5. A. P. candidum. 1. lateral view of flower 2. ovary 3. seed 4. and 5. two views of a teratological stamen-petal. The teratology is bilateral -- exactly one-half petal, one-half stamen. B. P. occidentale. 1. lateral view of flower. 2. ovary 3. seed. C. P. multiflorum. 1. lateral view of flower. 2. seed 3. standard -- slightly folded at the center of the blade due to the concave nature of the lamina. D. P. feayi and P. carneum. 1. lateral view of flower of P. feayi 2. standard of P. feayi 3. apical petal of P. feayi 4. seed of P. carneum

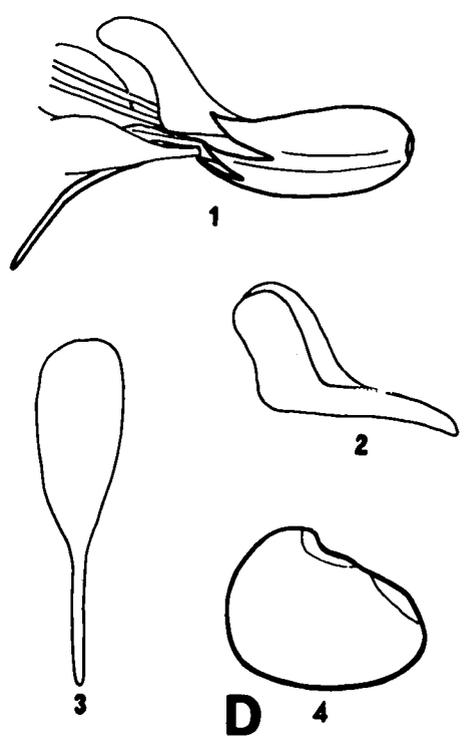
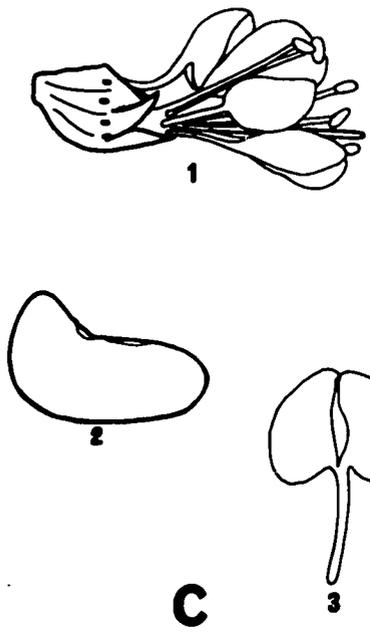
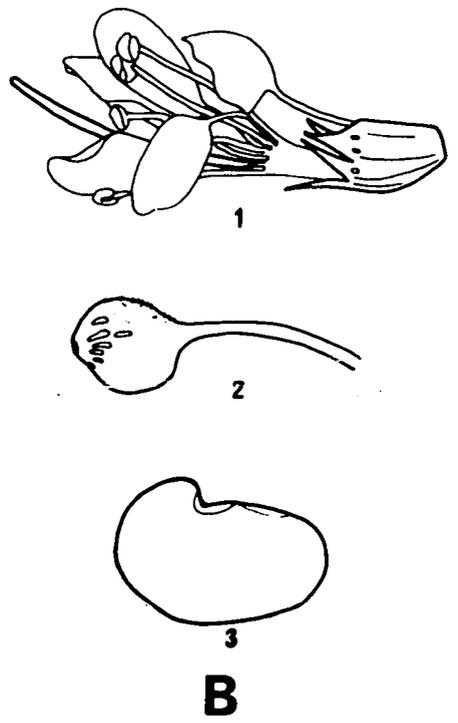
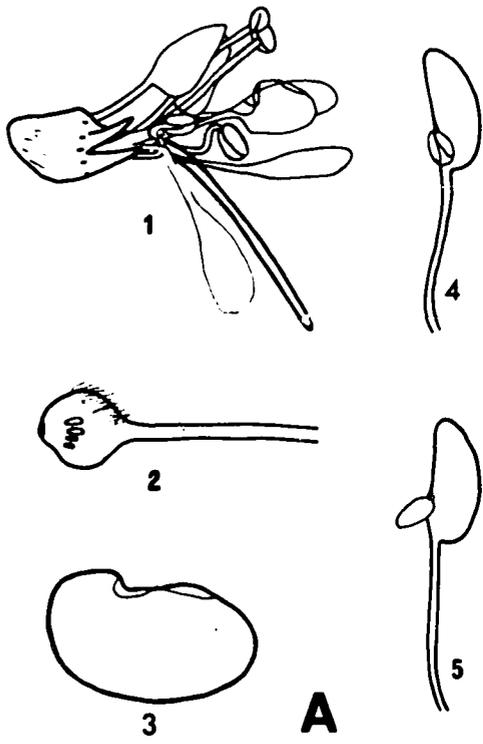


Fig. 52. Floral parts and seeds of selected species of sections Villosi, Phleoides, Foliosi and subg. Kuhnistera.

Seed drawings x15, other drawings x5.

- A. P. villosum. 1. lateral view of flower 2. bract
3. androecium and gynoecium with the standard removed
4. carpel 5. mature fruit, lateral view 6. mature
fruit dorsal view 7. legume 8. seed. B. P.
microphyllum. 1. lateral view of flower 2. seed.
C. P. caroliniense ssp. trifoliatum, seed
D. P. foliosum. 1. lateral view of flower
2. standard blade 3. apical petal

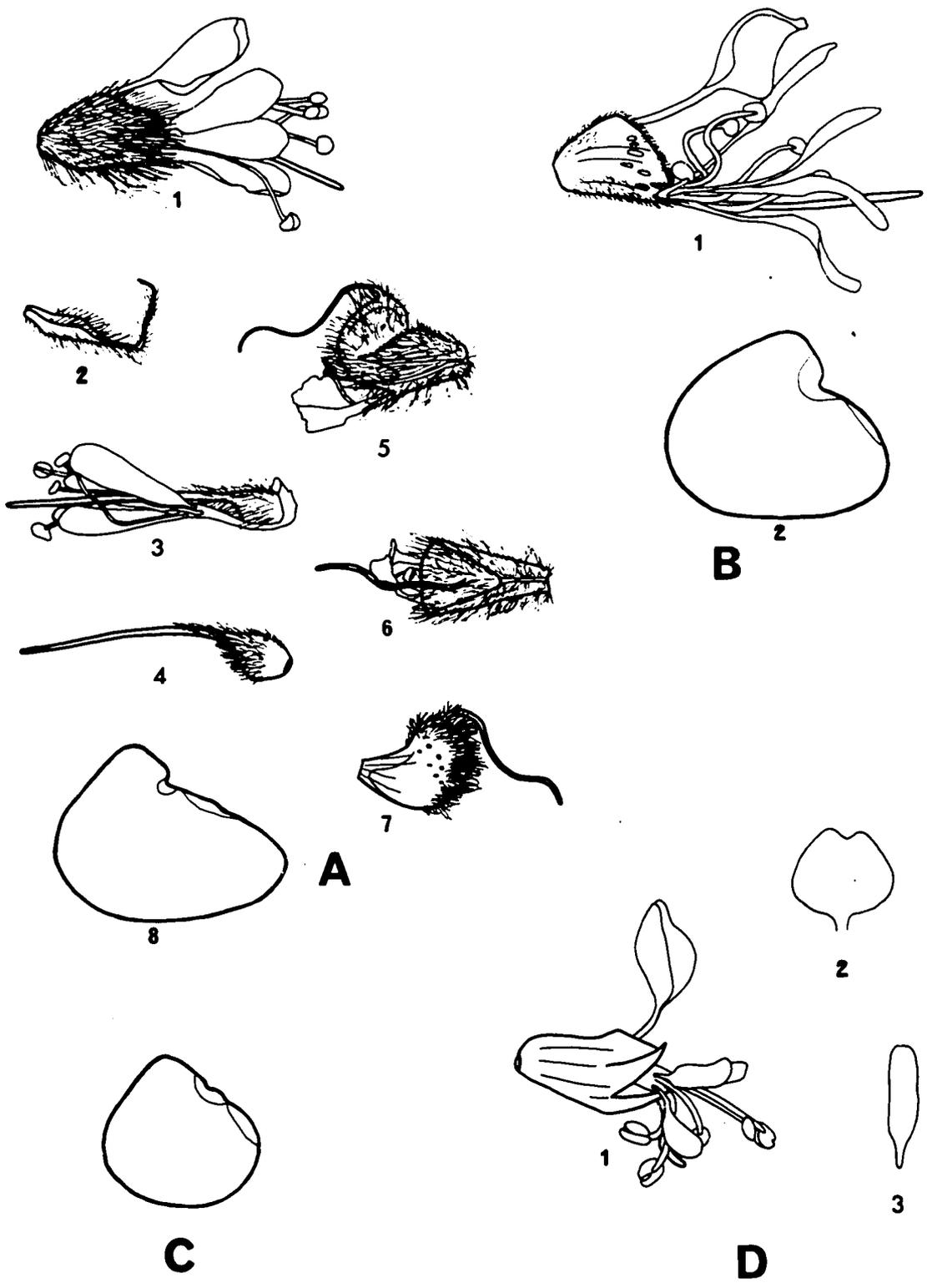


Fig. 53. Floral parts and seeds of species in section
Purpurei.

All floral drawings except I are x5. All seeds
and the petals in I are x15.

A. P. tenuifolium. 1. lateral view of flower
2. seed 3. androecium and gynoecium, standard
removed 4. carpel 5. bract.

B. P. decumbens. 1. lateral view of flower
2. seed.

C. P. purpureum, seed.

D. P. tenue, seed.

E. P. reverchonii, seed.

F. P. gattingeri, seed.

G. P. tenuifolium X P. gattingeri. 1. legume
2. fruit.

H. P. pulcherrimum, seed.

I. P. arenicola. 1. standard (folded in the
center due to concave shape) 2. apical petal

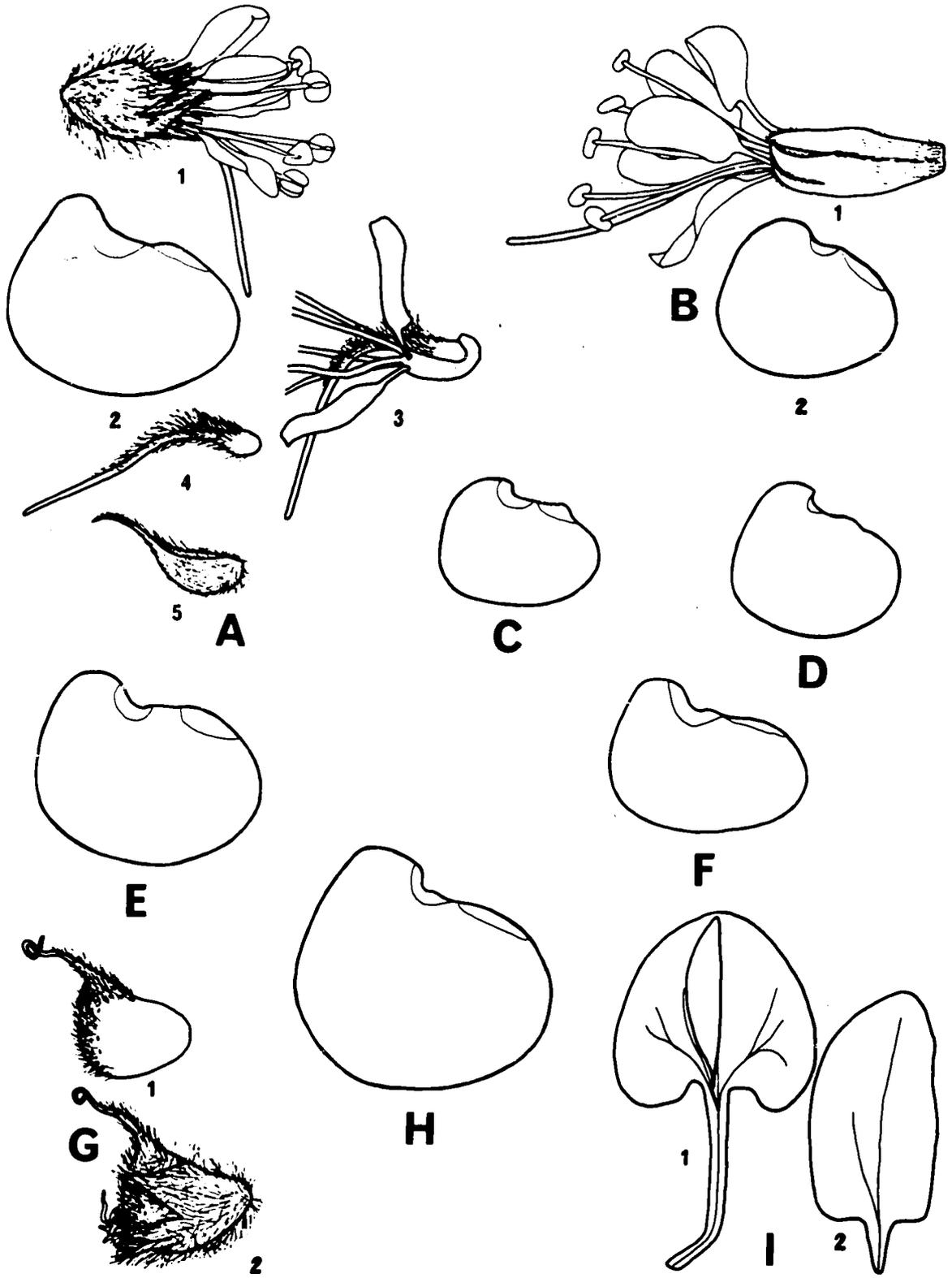


Fig. 54. Representative species of Petalostemon (A--E).
The caudex of a seedling of P. candidum (F).

- A. P. villosum
- B. P. candidum
- C. P. microphyllum
- D. P. arenicola
- E. P. obovatum



EXCLUDED SPECIES

All are annuals referable to Dalea (see pp. 14-31).

Petalostemon chiapense Brandg. Univ. Calif. Publ. Bot. 10: 408. (1924). Type in UC; isotype at US. (1)(2).

Petalostemon confusus Rydb. Fl. N. Am. 24: 129. (1919-1920). Type in US. (1)(2).

Petalostemon emarginatum T. & G. Fl. N. Am. 1: 311. (1838). Isotype in US. (1)(2).

Petalostemon evanescens (Brandg.) Rose. in Rydb. Fl. N. Am. 24: 129-130. (1919-1920). (2).

Petalostemon exile Gray. Pl. Wright 2: 41. (1853). Type in GH; isotype in US. (1)(2).

Petalostemon obreniformis Rydb. Fl. N. Am. 24: 130. (1919-1920). Type in US. (1)(2).

Petalostemum oreophilum Cory. Rhodora 41: 561-562. (1939). Type in GH; cotype in US. (1)(2).

Petalostemon tripetalus Wils. Kew Bul. 1958: 159. (1958). Type in US. (1)(2).

and

Petalostemon pilulosus Rydb. Fl. N. Am. 24: 128. (1919-1920). (2).

According to Kearney & Peebles (1960, p. 440):

Petalostemon pilosulus [sic] Rydb. was described from a specimen collected by Nealley (No. 237), probably in the Rincon Mountains, Pima County. The type appears to be a form of Dalea albiflora.

I have not seen the type.

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Finally, I wish to express my deep thanks to my wife, Mary, whose constant aid and encouragement resulted in the completion of this work.

LITERATURE CITED

- Anderson, L. E. 1954. Hoyer's solution as a rapid permanent mounting medium for Bryophytes. *The Bryologist* 57: 242-244.
- Barneby, R. C. 1965. Conservation and typification of Dalea. *Taxon* 5: 160-164.
- Bartling, F. G. 1830. *Ordines naturales plantarum*. Göttingen, Germany, Dieterich.
- Bowen, C. C. 1956. Freezing by liquid carbon dioxide in making slides permanent. *Stain Tech.* 31: 89-90.
- Brady, E. R., D. K. Wemple, and N. R. Lersten. 1964. Floral vasculature as a potential taxonomic character in Dalea (Leguminosae). *Iowa Acad. Jour. Sci.* 71: in press.
- Briquet, J., ed. 1912. *International rules of botanical nomenclature*. Jena, Germany, Fisher.
- Candolle, A. P. de. 1825. *Prodromus systematis naturalis regni vegetabilis*. Paris, France, Treuttel and Würtz.
- Creed, E. R., W. H. Dowdeswell, E. B. Ford, and K. G. McWhirter. 1959. Evolutionary studies on Maniola jurtina: the English mainland, 1956-57. *Heredity* 13: 363-392.
- Don, G. 1832. *General history of the dichlamydeous plants*. London, England, J. G. and F. Rivington.
- Endlicher, S. 1840. *Genera plantarum ordines naturales disposita*. Vindobonae, Germany, Frederick Beck.
- Erdtman, G. 1952. *Pollen morphology and plant taxonomy*. Waltham, Massachusetts, Chronica Botanica Co.
- Erdtman, G. 1954. *An introduction to pollen analysis*. Waltham, Massachusetts, Chronica Botanica Co.
- Fenneman, N. M. 1931. *Physiography of western United States*. New York, New York, McGraw Hill Book Co., Ltd.
- Gleason, H. A. 1952. *Illustrated flora*. Lancaster, Pennsylvania, Lancaster Press.

- Gould, F. W. 1962. Texas plants -- a checklist and ecological summary. Texas Agr. Expt. Sta. Bul. MP-585.
- Gray, A. 1849. Plantae Fendlerianae. Amer. Acad. Arts and Sci. Ser. 2, 4: 1-116.
- Gray, A. 1850. Plantae Lindheimerianae. II. Boston Jour. Nat. Hist. 6: 141-240.
- Harper, J. L., J. N. Clatworthy, I. H. McNaughton, and G. R. Sagar. 1961. The evolution and ecology of closely related species living in the same area. Evolution 15: 209-227.
- Heller, A. A. 1896. Notes on Kuhnistera. Tor. Bot. Club Bul. 23: 117-125.
- Hoagland, D. R. and D. I. Arnon. 1950. The water culture method for growing plants without soil. Calif. (Berkeley) Agr. Expt. Station Cir. 347.
- Hutchinson, J. 1964. The genera of flowering plants: Dicotyledones. Vol 1. Oxford, England, Clarendon Press.
- Isely, D. 1958. Leguminosae: Psoraleae of the United States: a generic summary. Iowa State Coll. Jour. Sci. 33: 23-36.
- Isely, D. 1962. Leguminosae of the north central states. IV. Psoraleae. Iowa State Jour. Sci. 37: 103-162.
- Isely, D. and S. L. Welsh. 1960. Petalostemon candidum and P. occidentale (Leguminosae). Brittonia 12: 114-118.
- Jackson, W. S. 1964. Revision of section Phleoides, Petalostemon (Leguminosae). Unpublished manuscript. Dept. of Botany and Plant Pathology, Iowa State Univ. Ames, Iowa.
- Jones, M. E. 1895. Contributions to Western botany. No. VII. Calif. Acad. Sci. Proceedings. Series 2. 5: 611-732.
- Jussieu, A. L. de. 1789. Genera plantarum. Paris, France, Herissant.
- Kearney, T. H. and R. H. Peebles. 1960. Arizona flora. Berkeley, California, University of California Press.
- Küchler, A. W. 1964. Potential natural vegetation of the conterminus United States. Amer. Geog. Soc. Sp. Publ. 36.
- Kuntze, O. 1891. Revisio generum plantarum. Liepzig, Germany, Arthur Felix.

- Lamarck, J. B. P. A. de Monet de. 1789. Encyclopedie methodique botanique. Paris, France, Panckoucke.
- Lanjouw, J., ed. 1961. International code of botanical nomenclature. 4th ed. Utrecht, Netherlands, Kemink and Zoon.
- Lanjouw, J. and F. A. Stafleu. 1964. Index herbariorum. Part 1. 5th ed. Utrecht, Netherlands, Kemink and Zoon.
- Ledingham, G. F. 1957. Chromosome numbers of some Saskatchewan Leguminosae with particular reference to Astragalus and Oxytropis. Canad. Jour. Bot. 35: 657-666.
- Lersten, N. R. and D. K. Wemple. The discontinuity plate, a definitive floral characteristic of the Psoraleae (Leguminosae). (to be published in Amer. Jour. Bot. ca. 1966.)
- Lindley, J. 1853. The vegetable kingdom. 3rd ed. London, England, Bradbury and Evans.
- Linné, C. von. 1737. Genera plantarum. Lugduni Batavorum, Sweden, C. Wishoff.
- Michaux, A. 1803. Flora boreali-americana. Paris, France, Levrault.
- Moore, J. A. 1936. The vascular anatomy of the flower in the papilionaceous Leguminosae. I. Amer. Jour. Bot. 23: 279-290.
- Pfeiffer, H. 1928. Die pflanzlichen Trennungsgewebe. In K. Linsbauer. Handbuch der Pflanzenanatomie. Band 5, Lief 22. Berlin, Germany, Vorlag von Gebrüder Borntraeger.
- Pohl, R. W. 1954. A rapid softening agent for dried plant structures. Iowa Acad. Sci. Proc. 61: 149-150.
- Poiret, J. L. M. 1804. Encyclopedie methodique botanique. Paris, France, H. Agasse.
- Poiret, J. L. M. 1818. Dictionnaire des sciences naturelles. Paris, France, Le Normant.
- Porter, C. L. 1957. U. S. Dept. of Agriculture (Beltsville, Maryland). Leguminosae of Nevada. Contributions Toward a Flora of Nevada No. 42, Part 3: 1-69.

- Pursh, F. 1814. *Flora Americae septentrionalis*. London, England, White, Cochrane and Co.
- Quarterman, E. 1950. Ecology of cedar glades. I. Distribution of glade flora in Tennessee. *Torr. Bot. Club Bul.* 77: 1-9.
- Radford, A. E., H. E. Ahles, and C. R. Bell. 1964. *Guide to the vascular flora of the Carolinas*. Chapel Hill, North Carolina, the Book Exchange, Univ. of N. Carolina.
- Rickett, H. W. and F. A. Stafleu. 1961. *Nomina generica conservanda et rejicienda spermatophytorum*. 8. Bibliography. *Taxon* 10: 111-121.
- Rollins, R. C. 1956. The problem of Leavenworthia aurea. *Rhodora* 58: 73-76.
- Rollins, R. C. 1963. The evolution and systematics of Leavenworthia (Cruciferae). *Gray Herbarium of Harvard University Contr.* 192: 1-135.
- Rydberg, P. A. 1919-1920. Fabaceae: Psoraleae. In *North American Flora*. Vol. 24. New York, New York, New York Botanical Garden.
- Rydberg, P. A. 1928a. Genera of North American Fabaceae. 3. Tribe Psoraleae. *Amer. Jour. Bot.* 15: 195-203.
- Rydberg, P. A. 1928b. Genera of North American Fabaceae. 4. Tribe Psoraleae. *Amer. Jour. Bot.* 15: 425-432.
- Sass, J. E. 1958. *Botanical microtechnique*. 3rd ed. Ames, Iowa, Iowa State University Press.
- Schubert, B. G. 1942. Willdenow's *Species Plantarum* and Michaux's *Flora Boreali-Americana*: dates of publication. *Rhodora* 44: 147-150.
- Sen, N. K. and R. Krishnan. 1961. Binucleate pollen mother cells in Clitoria ternata. *Current Sci.* 30: 306-307.
- Sharsmith, H. K. 1961. The genus Hesperolinon (Linaceae). *Univ. Calif. Publs. Bot.* 32: 235-314.
- Shinners, L. H. 1949a. Transfer of Texas species of Petalostemum to Dalea (Leguminosae). *Field and Lab.* 17: 81-85.
- Shinners, L. H. 1949b. The genus Dalea (including Petalostemum) in north-central Texas. *Field and Lab.* 17: 85-89.

- Shinners, L. H. 1964. How to study the Florida flora. *Sida* 1: 257-261.
- Small, J. K. 1903. Flora of the southeastern United States. New York, New York, publ. by the author.
- Small, J. K. 1933. Manual of the southeastern flora. New York, New York, publ. by the author.
- Stone, D. E. 1963. Pollen size in Hickories (Carya). *Brittonia* 15: 208-214.
- Torrey, J. and A. Gray. 1838. Flora of North America. New York, New York, Wiley.
- Turner, B. L. 1956. Chromosome numbers in the Leguminosae. I. *Amer. Jour. Bot.* 43: 577-581.
- Turner, B. L. 1959. The legumes of Texas. Austin, Texas, Univ. of Texas Press.
- Turner, B. L. 1963. Chromosome count. In Documented chromosome numbers of plants. *Madroño* 17: 116.
- Turner, B. L. and O. S. Fearing. 1960. Chromosome numbers in the Leguminosae. III. Species of the southwestern United States and Mexico. *Amer. Jour. Bot.* 47: 603-608.
- Ventenat, E. P. 1799a. Tableau du regne vegetal, selon la methode de Jussieu. Paris, France, J. Drisonnier.
- Ventenat, E. P. 1799b. Dissertation sur le genre Dalea. *Soc. Hist. Nat. Paris Mem.* 1: 111-113.
- Ventenat, E. P. 1800. Description des plantes nouvelles et peu connues, cultivées dans le jardin de M. Cels. Paris, France, de Chapelet.
- Walter, T. 1788. Flora Caroliniana. London, England, J. Fraser.
- Wiggins, I. L. 1940. Taxonomic notes on the genus Dalea Juss. and related genera as represented in the Sonoran Desert. *Dudley Herbarium of Stanford University Contributions* 3: 41-55.
- Wilbur, R. L. 1963. The leguminous plants of North Carolina. *North Carolina Agr. Expt. Station Tech. Bul.* 151.
- Willdenow, K. L. 1802. *Species plantarum*. Vol. 3. Berlin, Germany, G. C. Nauk.

APPENDIX

Cited SpecimensPetalostemon adenopodum -- specimens examined

Florida: County unknown. Chapman -- (US). Brevard. Fredholm 5628 (US). Broward. Davis 28 October 1941 (FLAS); Kent 24 October 1942 (FSU); Small & Carter 1041 (NY). Collier. Hardin et al 14080 (GA). Highlands. Isely & Wemple 9323 (ISC); McFarlin 11667 (FLAS). Hillsborough. Blanton 6807 (NO); Garber October 1877 (NY, FSU). Martin. West & West 9 November 1945 (FSU). Okeechobee. Isely & Wemple 9332 (ISC). Orange. O'Neill 18 September 1929 (FLAS); Schallert 20850 (FLAS). Osceola. Isely & Wemple 9344 (ISC). Pinellas. Deam 2817 (NY, US). St. Johns. Reynolds October 1874 (NY); Reynolds July 1877 (US); McReynolds 10025 (NY). St. Lucie. Small et al 2307 (NY).

Petalostemon albidum -- specimens examined

Florida: County unknown. Garber November 1877 (NY); Palmer year 1874 (MO, NY). Alachua. Isely & Wemple 9257 (ISC); Loucks & West 25 September 1927 (FLAS); Murrill 29 August 1939 (DUKE, MO); Murrill 149 (US); Small et al 10584 (NY, US). Bradford. Dennison & Arnold 112 (FLAS). Columbia. Rolfs 105 (FLAS); West & Arnold 112 (FLAS). Dixie. Arnold 8 October 1937 (FLAS); Isely & Wemple 9238 (ISC). Duval. Biltmore 14941 (NY); Curtiss 567 (GA, MO, NY, SMU, US); Curtiss 4224 (MO, NY, US); Curtiss 5200 (GA, ISC, NY, US); Lighthipe 496 (NY). Gadsden. West 8 September 1931 (FLAS); West 9 September 1931 (FLAS). Gilchrist. Godfrey 56004 (FSU). Lee. Small (NY). Leon. Berg, near Tallahassee (NY); Godfrey 53927 (FSU); Godfrey 58850 (FSU). Levy. Garber no number or date (NY); Garber November 1877 (FSU, US); Godfrey 50862 (SMU); Isely & Wemple 9263 (ISC). Marion. Burger & West 15 September 1927 (FLAS). Polk. McFarlin 6390 (FLAS). Suwannee. Isely & Wemple 9372 (ISC); Murrill 21 August 1939 (FLAS); Murrill 748 (ISC, US). Wakulla. Rugel 167 (NY).

Georgia: Baker. Duncan 4113 (GA). Bibb. Smith 1870 (US). Brooks. Duncan 2967 (GA). Bullock. Harper 873 (US). Colquitt. Duncan 17122 (GA). Dougherty. Pollard & Maxon 509 (ISC, NY, US). Early. Thorne 6429 (GA). Lowndes. Quarterman 461 (DUKE). Randolph. Harper 1781 (NY, US). Sumter. Harper August 1897 (NY); Harper 433 (NY, US). Taylor. Neisler, Butler / Elliott's localli (NY); Pyron & McVaugh 1301 (GA). Ware. Sargent 77 (US).

Petalostemon arenicola -- specimens examined

State unknown: County unknown. Wood, no date or number (NY).

Colorado: Cheyenne. Ripley & Barneby 10164 (NY). Las Animas. Rogers 6002 (US). Lincoln. Marsh 9 July 1907 (US). Yuma. Eggleston 15169 (MO); Osterhout 4017 (RM); Osterhout 4082 (RM); Piemeisel 1511 (US); Shattz 593 (US); Shantz & Piemeisel 1459 (US).

Kansas: Clark. Rydberg & Imler 786 (NY). Comanche. Rydberg & Imler 718 (NY). Finney. Coville 15 (NY, US). Hutchinson. Wemple 297, 298 (ISC). Kearney. Rydberg & Imler 926 (NY); Wemple 314, 316, 318, 319 [Type] (ISC). Meade. Horr 3524 (US). Morton. Hulbert 3231 (OKLA). Pawnee. Horr 4017 (US). Pratt. Wemple 306 (ISC). Stevens. Swink 44 (NY).

Nebraska: Chase. Welsh 707 (ISC). Deuel. Rydberg 59-60 (NY). Lincoln. Porter 2016 (RM). Sioux. Welsh 727 (ISC).

New Mexico: Lea. Shinnars 30068 (ISC). Quay. Fisher 13 (US). Roosevelt. Goodman & Hitchcock 1116 (NY); Wooten 17 August 1909 (US).

Oklahoma: Beaver. Hindman 218 (OKLA). Cimarron. Waterfall 9055 (OKLA). Harmon. Waterfall 8970 (ISC, OKLA). Harper. Welsh 677 (ISC). Roger Mills. Welsh 690 (ISC). Ellis. Welsh 682 (ISC).

Texas: Andrews. Isely 5862 (ISC). Bailey. Cory 37482 (OKLA); Howell 8244 (SMU). Childress. (Bio. Class C. H. S.) July (TEX). Dallam. Griffiths 5665 (US); Wemple 340 (ISC). Donley. Reverchon 3007 (NY); Reverchon 3007 (NY); Shinnars 15211 (SMU). Floyd. Ferris & Duncan 3360a (NY). Gaines. Tharp 128d (TEX). Hemphill. Howell 4216 (SMU); Wemple 380 (ISC). Hutchinson. Shepard 50 (TEX); Thornton 52-398 (RM, TEX). Lipscomb. Howell 16 (US); Wallis 7243 (OKLA, SMU). Lubbock. Tharp 7113 (OKLA, TEX, US). Moore. Wemple 351 (ISC). Oldham. Ferris & Duncan 3510 (NY). Potter. Wemple 357 (ISC); York & Rogers 28 (OKLA, TEX). Randall. Bottimer 11 June 1954 (TEX). Roberts. Wallis 7854 (OKLA). Wheeler. Tharp 7109 (TEX, US).

Petalostemon candidum -- representative specimens examinedCANADA

Manitoba: Love & Love 5627, W of Brokenhead (US); Fowler 6 July 1887, Brandon (US).

Ontario: Denike 577, Ingolf (NY).

Saskatchewan: Ledingham & Yip 2244 (ISC); Bourgeau year 1857-8 (NY).

UNITED STATES

Alabama: Colbert, Isely 3741 (ISC); Greene. Harper 3426 (NY, US); Sumter, Crawford & Harvill 1133 (TEX).

Arkansas: Baxter, Demaree 30835 (ISC, SMU, TEX); Benton, Plank year 1899 (NY); Boone, Demaree 3218a (SMU); Carroll, Iltis 4868 (OKLA, SMU, TENN); Conway, Demaree 37154 (SMU); Fulton, Demaree 30803 (ISC, SMU, TEX); Garland, Demaree 23203 (ISC, NY, OKLA, SMU, TENN); Logan, Demaree 17680 (NY, SMU); Lonoke, Demaree 22358 (NY, SMU); Marion, Demaree 30915 (ISC, OKLA, SMU, TEX); Pulaski, Merrill 39 (FSU); Searcy, Demaree 22254 (NY, SMU); Washington, Demaree 3183 (TEX).

Illinois: Champaign, Reynolds 566 (US); Cook, Babcock 15 June 1871 (US); Dupage, Umbach 4 July 1896 (RM); Hancock, Mead August 1844 (NY); Henderson, Patterson, Oquawka (NY); Kane, Eldredge 18 July 1888 (ISC); Macon, Clokey 2395 (NY, OKLA, RM); Menard, Hall July 1863 (NY); Ogle, Waite 3 August 1885 (DUKE, US); Peoria, Chase 3186 (ISC, NY); St. Clair, Herzog year 1878 (NY); Winnebago, Bebb year 1867 (NY).

Indiana: County unknown, Umbach 5728, Millers (ISC); Umbach 20 August 1898, Clarke (US); Stuart 7 July 1900, Elston; Cass, Friesner 9740 (DUKE, GA, NY, SMU, TENN); Newton, Friesner 22885 (FLAS, KY, TEX); Vigo, Evermann year 1889 (US).

Iowa: Adair, Morrill 144 (ISC); Allamakee, Shimek 13 August 1917 (ISC); Appanoose, Davidson 2620 (ISC); Black Hawk, Carver year 1894 (ISC); Boone, Isely 5262 (OKLA, US); Buchanan, Bode 13 August 1919 (ISC); Buena Vista, Pammel 31 July 1908 (ISC); Carroll, Hayden 3446 (ISC); Cerro Gordo, Shimek 29 July 1922 (NY); Chickasaw, Spiker 12 July 1926 (ISC); Clarke, Pammel 26 September 1924 (ISC); Clay, Hayden 7666 (ISC); Clayton, Shimek 19 August 1922; Crawford, Isely 4194 (ISC); Decatur, Anderson 1 August 1903 (ISC, RM); Deleware, Shimek 18 July 1928 (ISC); Des Moines, Pammel 948 (ISC); Dickinson, Thorne 12996 (US); Cherokee, Pammel 5 September 1920 (ISC); Dubuque, Pammel 16 August 1907 (ISC); Emmett, Cratty July 1895 (US); Fayette, Fink 218 (US); Fremont, Gleason 9296 (NY); Guthrie, Monson 2547 (ISC); Hamilton, Pammel 29 July 1927 (OKLA); Hancock, Hayden 3442 (ISC); Hardin, Jones August 1876 (NY, US); Harrison, Scribner year 1875 (US); Howard, McDill 289 (ISC); Humboldt, MacBride 1898 (ISC); Ida, Pammel July 1896 (ISC); Iowa, Shimek 12 July 1913 (ISC); Jasper, Bruggen 587 (FLAS); Johnson, Shimek 14 July 1923 (NY); Jones, Isely 5903 (ISC); Kossuth, Martin 95 (ISC); Linn, Shimek 2 July 1921 (ISC); Louisa, Shimek 24 August 1926 (ISC); Lyon, Shimek 27 August 1932 (NY); Mills, Morrill 976 (ISC); Mitchell, Tuttle 10 (ISC); Minona, Shimek 19 July 1909 (ISC); Muscatine, Shimek 14 July 1911 (NY); O'Brien, Hayden 3450 (ISC); Osceola, Monson 2290 (ISC); Palo Alto, Hayden 4033 (ISC, NY); Pocahontas, Monson 2677 (ISC); Pottawattamie, Clawson 309 (ISC); Poweshiek, Russell 712551 (TENN); Sac, Monson 2620a (ISC); Scott, Shimek 8 August 1927 (ISC); Shelby, Shimek 24 August 1913 (ISC); Sioux, Hayden 4040 (ISC); Story, Wingo 191 (SMU); Warren, Bruggen 1255 (SMU); Webster, Churchill

2109 (ISC); Winnebago, Monson 2861 (ISC); Winneshiek, Holway 43 (ISC); Woodbury, Gleason 9334 (NY); Worth, Shimek 25 August 1928 (ISC); Wright, Shimek 9 August 1919 (ISC).

Kansas: Bourbon, Hulbert 3761 (OKLA); Cherokee, Rydberg & Imler 273 (NY); Douglas, Chamney 5 (SMU); Franklin, Welsh 662 (ISC); Geary, Wemple 295 (ISC); Harvey, Biltmore 17 June 1896 (NY, US); Labette, McGregor 16986 (SMU); Linn, Isely 7449 (ISC); Pottawatomie, Marsh 1720 (SMU); Reno, Smyth 36 (US); Riley, Norton 95 (NY, RM, US); Saline, Demaree 29374 (ISC, SMU, TEX); Sedgwick, Bartley 1128 (ISC, NY).

Kentucky: County unknown, Short year 1842 (NY); Logan, Braun 3539 (NY); Lyon, Eggleston 4835 (NY); Nelson, Wharton 5574 (KY); Trigg, Baker 17 (FSU).

Louisiana: Acadia, Shinnars 23631 (SMU); Calcasieu, Cocks 5 November 1912 (NO); LaSalle, Shinnars 23985 (SMU); Natchitoches, Ware 24 June 1956 (SMU, TEX); Rapides, Ball 622 (ISC, NY, US).

Minnesota: Big Stone, Gleason 9436 (NY); Brown, Isely 8169 (ISC); Cass, Pammel 70 (ISC); Chicago, Taylor August 1892 (RM); Clay, Solheim 255 (RM); Clearwater, Grant 3003 (NY, US); Hennepin, Schuette 1. 39. 43. (NY, US); Kittson, Johnson 463 (ISC, NY); Nicollet, Ballard July 1892 (RM, US); Ottertail, Chandonnet 26 July 1911 (RM); Ramsey, Brown 53-44 (ISC); Redwood, Isely 8150 (ISC); Rice, Goldsmith G101 (NY); St. Louis, Lakela 2585 (NY, SMU); Sherburne, Isely 6352 (ISC, SMU); Stevens, Moore & Huff 19066 (SMU); Todd, Schuster 27 June 1947 (FSU); Winona, Hasse 24 July 1882 (NY).

Mississippi: Clarke, Harper 3241 (NY, US); Lee, McDougall 1702 (US); Newton, Kral 9002 (FSU); Oktibbeha, Mohr 17 June 1892 (NY).

Missouri: Franklin, Mason 1 (TEX); Greene, Redfearn 3738 (FSU); Jackson, Bush 457 (US); Lewis, Gleason 9237 (NY); Livingston, Sparling 1110 (ISC); Ozark, Palmer 34747 (US); Phelps, Kellogg 111 (NY); St. Louis, Letterman year 1880 (ISC, NY, TEX); Stone, Isely 7004 (ISC); Sullivan, Gleason 9263 (NY); Taney, Isely & Wemple 9010 (ISC).

Nebraska: Adams, Barnhart 465 (NY); Buffalo, Rydberg 58 (NY); Cass, Morrison 1111 (US); Deuel, Rydberg 58 (NY); Hall, Isely 6084 (ISC, NY); Knox, Clements 2699 (US); Lancaster, Webber July 1888 (NY); Pawnee, Mohler 26 June 1941 (ISC); Webster, Tolstead 411023 (ISC).

North Dakota: Barnes, Fattig 2857 (DUKE); Benson, Lunell 11 August 1907 (NY); Dickey, Bergman 706 (RM); McHenry, Brown 53-49 (ISC); Richland, Metcalf 105 (NY); Rolette, Turfte 197 (RM).

Oklahoma: Adair, Wallis 7485 (OKLA, SMU, TEX); Bryan, Cory 58856 (ISC, OKLA, SMU); Carter, Penny 20 (TEX); Cherokee, Wallis 2334 (OKLA); Chootaw, Wemple & Jackson 595 (ISC); Delaware, Wallis 3273 (OKLA); Garvin, Duffer 529 (OKLA); Kay, Byler 423 (OKLA); Mayes, Wallis 2981 (OKLA); McCurtain, Little & Olmsted 53 (OKLA); Murray, Duffer 418

(OKLA); Muskogee, Wallis 4380 (OKLA); Oklahoma, Waterfall 2084 (OKLA); Osage, Webster 4271 (OKLA, SMU); Ottawa, Wallis 4637 (SMU); Payne, Briscoe 17 July 1937 (OKLA); Pittsburg, Shinners 18863 (SMU); Pottawatomie, McLean 183 (TEX); Sequoyah, Wallis 7469 (SMU, TEX).

South Dakota: County unknown, Vasey 16 August 1906 (US); Hanson, Weber 17 August 1927 (FLAS); Turner, Johnson 48 (ISC, NY).

Tennessee: Davisdon, Gattinger year 1877 (US); Rutherford, DeSelm 1847 (TENN).

Texas: Bastrop, Lundell & Lundell 9055 (US); Caldwell, MoBryde 12 June 1931 (OKLA, TEX); Dallas, Reverchon 3751 (NY, SMU, US); Fannin, Van Vleet 1577 (SMU, TEX); Grayson, Gentry 50-227 (FLAS, TEX); Galveston, Turner 2191 (SMU); Hardin, Wemple & Jackson 693 (ISC); Harris, Reverchon 3752 (SMU); Hopkins, Shinners 20431 (SMU); Jasper, Cory 56593 (SMU); Lamar, Reese (SMU, TEX); Lee, Hall 135 (NY, US); Liberty, Wemple & Jackson 694 (ISC); Palo Pinto, Tracy 6 June 1902 (TEX); Red River, Tharp 47391 (ISC, TEX); Smith, Shinners 11425 (SMU); Tarrant, Ruth 194 (TEX).

Wisconsin: Dane, Seymour & Jones 1040 (DUKE); Juneau, Mearns 231 (NY, US); LaCrosse, Pammel year 1887 (ISC); Outagamie, Leuders 13 July 1889 (US); Sauk, Grotjan 172 (TENN).

Petalostemon carneum -- specimens examined

Florida: County unknown. Britton 304 (NY); Chapman year 1871 (NY); Chapman year 1901 (US); Chapman 719 (US); Cooper year 1859 (NY); Curtiss year 1875 (NY); Keeler 7 October 1905 (NY); Lighthipe 242 (NY); McFarlin 17 July 1927 (FLAS); Palmer year 1874 (NY, US); Palmer 106 (MO, NY); Safford 14 July 1917 (US); Simpson year 1889 (US). Bradford, Murrill & Watson 112 (FLAS). Brevard, Fredholm 5917 (MO, US); Kral 5280 (FLAS); Rhoads (FLAS). Broward, Hood 28 April 1910 (FLAS); Small & Carter 1205 (NY); Small et al 3375 (NY). Charlotte, Bennett 11 July 1959 (FLAS); Gaiser et al 18 August 1945 (FLAS); Kral 17877 (Louisiana Polytechnic Institute). Citrus, Isely & Wemple 9271 (ISC); Kral 7759 (GA); Kral 7815 (FSU, NY). Clay, Knight 2 July 1936 (FLAS); Murrill 308 (US); Murrill 309 (MO, US). Collier, Brass 15914 (US); Kral 18102 (Louisiana Polytechnic Institute). Dade, Britton 276 (NY); Garber April - June 1877 (FSU, NY, US); Kral 18074 (Louisiana Polytechnic Institute); McAllister 243a (DUKE); Meredith March 1917 (TENN); Moldenke 295 (MO, NY); Moldenke 310 (DUKE, US); Pollard & Collins 255 (NY, US); Small 3844 (NY); Small 3873 (NY); Small & Carter 739 (NY); Small & Carter 744 (NY); Small & Mosier 6344 (NY); Small & Nash 177 (NY); Small & Wilson 1816 (NY); Small et al 3253 (NY); Small et al 5969 (NY). Dixie, Arnold 16 August 1937 (FLAS); Isely & Wemple 9230 (ISC); Kral 5384

(FLAS). Duval. Curtiss year 1875 (US); Curtiss July 188- (NY); Curtiss 567 (NY, SMU, US); Curtiss 568 (NY); Curtiss 4226 (NY, US); Curtiss 5028 (GA, ISC, NY, US); Fredholm 5342 (US); Nash (MO, FSU, NY, US). Flagler. Kral 18551 (Louisiana Polytechnic Institute). Gilchrist. Murrill 14 August 1939 (FLAS). Hardee. Sargent 6581 (OKLA). Hernando. Hardin 291 (GA); Jones 32 (US). Highlands. Brass 15368 (US). Hillsborough. Blanton 6720 (MO); Deam 2736 (US); Fredholm 6364 (MO, US); Hood 4051 (FLAS); Kral 7372 (FLAS, NY); Lewton 5 August 1894 (NY). Indian River. Small 8908 (DUKE, FLAS, TENN). Lee. Correll 5897 (DUKE); Hitchcock 75 (MO, NY, US); Isely 6703 (ISC); Standley 280 (MO, NY, US). Levy. Knight 16 September 1943 (FSU); Murrill 10 September 1939 (DUKE); Murrill 619 (ISC, US); Perdue 1720 (FSU, US). Manatee. Guthbert 25 July 1916 (FSU); Guthbert 1380 (FSU); Kelbert 5 December 1934 (FSU); Rugel 168 (NY); Tracy 7730 (ISC, MO, NY, US). Nassau. Knight 28 July 1941 (FLAS). Okeechobee. Isely & Wemple 9332 (ISC). Orange. Lewton 2461 (NY); Rhoads 3 September 1937 (FLAS). Osceola. Singletory 4 September 1937 (DUKE). Pasco. Burger & West 16 September 1927 (FLAS); Isely & Wemple 9282 (ISC); Isely & Wemple 9285 & 9285a (ISC); Kral 7409 (FLAS, FSU, GA); O'Neill 1129 (US). Pinellas. Godfrey 50846 (ISC, TENN); Godfrey & Kral 53813 (FSU). Polk. Berry 199 (TENN); Isely & Wemple 9308 (ISC); McFarlin 6379 (FLAS); Redfearn 2687 (FSU); Weber & Kelbert (FLAS). St. Johns. Reynolds (NY, US); Tracy 9082 (MO, NY). St. Lucie. Small & Matthaus 26 April 1920 (NY). Seminole. Kral 5198 (FSU); Shallert 54414 (FLAS). Sumter. Kral 7924 (FSU, NY, US). Taylor. Godfrey 52410 (FSU); Godfrey & Hauk 60291 (FSU); Isely & Wemple 9229 (ISC). Volusia. Bottimer 567 (GA); Dowell 7602 (NY); Hood 20 May 1911 (FLAS, MO); Hume 11 August 1935 (FLAS); Kral 18458 (Louisiana Polytechnic Institute); Richardson year 1939 (DUKE).
 Georgia: Camden. Dress 856 (FLAS, GA); Hood 4370 (FLAS); Small et al 10551 (US). Charlton. Correll 5490 (DUKE, FSU, GA, TENN); Harper 1493 (MO, NY, US); Small 24-26 July 1895 (ISC, NY).

Petalostemon caroliniense ssp. caroliniense -- specimens

examined

Florida: County unknown. Hood 30 September 1913, Orange City (FLAS); O'Neill 25 October 1925, Ft. Leo (MO); Singletory 7 October 1936, Loughman to Lake Wilson (DUKE); Smith 26 November 1871, Pilatka (NY). Alachua. Arnold 12 October 1931 (FLAS); Fattig 6 (US); Isely & Wemple 9246 (ISC); Murrill 12 October 1937 (MO); Murrill 440 (US); O'Neill 24 October 1924 (FLAS); Weber & West 30 September 1927 (FLAS); West & Arnold 21 September 1937 (FLAS). Citrus. Brass 20819 (US); Isely & Wemple 9267 (ISC). Clay. Watson & Murrill 29 October 1939 (FLAS). Columbia. Isely & Wemple 9368 (ISC); Perdue 1823

(FSU, US); Rolfs 369 (FLAS, MO). Dixie. Godfrey 58790 (FSU); Isely & Wemple 9239 (ISC); Murrill 8 October 1940 (FLAS). Duval. Blake 8 September (FLAS); Curtiss 571 (GA, MO, NY, US); Curtiss 4225 (MO, US); Curtiss 5307 (GA, ISC, NY, US); Lighthipe 495 (DUKE, NY). Franklin. Kurz 1 November 1941 (FLAS). Gilchrist. Isely & Wemple 9241 (ISC); West & Arnold 5 October 1940 (FLAS). Highlands. Brass 15677 (US); Brass 18149 (FLAS, US). Hillsborough. Isely & Wemple 9286 (ISC); Lakela 23505 (FLAS); Lakela & Patman 10636 (DUKE). Jefferson. Godfrey & Morrill 52548a (FSU). Lake. Murrill 13 October 1940 (FLAS). Leon. Jackson 2 October 1949 (FSU); Rugel September 1845 (NY). Levy. Ford 2346 (TENN); Isely & Wemple 9264 (ISC); Murrill 10 September 1939 (FSU). Madison. Kral 6179 (DUKE, FSU). Marion. Murrill 17 September 1939 (MO); Murrill 695 (US); Murrill 13 October 1940 (FLAS). Orange. Blanton 6470 (DUKE); Meislahn 111 (US); Moldenke 192 (DUKE, MO, NY); Schallert 1251 (FSU); Tisdale year 1932 (MO). Pasco. Barnhart 2874 (NY); Isely & Wemple 9283 (ISC). Pinellas. Tracy 7722 (ISC, MO, NY, US). Polk. Bottimer 578 (GA); McFarlin 726 (FSU); Milligan November 1890 (US); Young November 1917 (US). Putnam. Barnhart 1269 (NY); Fox 5690 (GA, ISC, TENN, US); Isely & Wemple 9356 (ISC); Laessle 20 October 1940 (FSU). Seminole. Godfrey 50884 (DUKE). Taylor. Small (FSU, DUKE, MO, TENN, US).

Georgia: County unknown. Jones 4470 (MO). Brooks. Duncan 2956 (FLAS, GA). Bryan. Eyles 6505 (GA). Charlton. Proctor year ca. 1941 (GA). Colquitt. Harper 1671 (MO, NY, SU). Lowndes. Quarterman 467 (DUKE). Richmond. Cronquist 4729 (NY). Wayne. Duncan 7856 (FLAS, GA, MO, TENN, US).

North Carolina: Bladen. Oosting & Blomquist 33644 (DUKE). Brunswick. no collector listed, near Wilmington (NY). Cumberland. Fox 1029 (FLAS, TENN); Fox & Godfrey (FLAS, FSU, GA, ISC, MO, OKLA, TENN, US); Kral 3403 (FSU). Harnett. Blomquist 10163 (DUKE); Godfrey 50118 (FLAS, ISC, TENN); McCarthy 5 September 1889 (US). Hoke. Ales 36492 (FLAS). Moore. Oosting 34756 (DUKE). Pender. Ales 36324 (GA). Richmond. Cronquist 4729 (FLAS, GA, MO, US); Fox & Godfrey 4275 (ISC); Radford 19291 (OKLA). Robeson. Ahles 37268 (FSU); Terrell 2996 (DUKE).

South Carolina: Aiken. Ahles & Crutchfield 55582 (ISC); Ravenel 20 September 1886 (MO); Ravenel September 1869 (US). Chesterfield. Godfrey 8001 (DUKE, MO, NY, TENN, US). Darlington. Norton 508 (MO). Dorchester. Gibbs 7-8- October 1859 (NY). Hampton. Bell 5355 (KY, TENN). Marlboro. Fox & Godfrey 4260 (GA, ISC, TENN, US).

Petalostemon carolinense ssp. trifoliatum -- specimens examined

Alabama: County unknown. Buckley September 1821 (MO); Gates year 1831 (NY); Graves 1109, Spring Hill (MO, US); Mohr 1 October 1886, Spring Hill (US). Baldwin. Isely & Wemple

9125 (ISC). Covington. Hardin et al 14175 (GA). Mobile.
 Mohr year 1878 (NY); Mohr 1879 (US); Oosting 1997 (DUKE);
 Whitehouse 23940 (FSU).

Florida: County unknown. Curtiss 6934, Argyle (GA, MO,
 NY, US). Bay. Billington 75 (US); Godfrey 60331 (FSU); God-
 frey & Kral 54175 (FSU, NY). Calhoun. Hood 2698 (FLAS).
Escambia. Isely & Wemple 9143 (ISC); Kral & Godfrey 6131 (FSU).
Franklin. Chapman 818 (NY, US); Chapman 6097 (NY, US); Laurman
 year 1867 (NY). Gadsden. Murrill 6 October 1940 (FLAS).
Holmes. Isely & Wemple 9177 (ISC). Jackson. Hood 2566 (FLAS).
Leon. Clewell 758 (ISC). Liberty. Kurz & Hardin 6 October
 1951 (FLAS). Okaloosa. Hood 3193 (FLAS); Isely & Wemple 9158
 (ISC). Santa Rosa. Houk & Godfrey 706 (FSU); Isely & Wemple
 9146 (ISC). Walton. Godfrey 55247a (FSU); Hume 17 September
 1938 (FLAS); Isely & Wemple 9170 (ISC); Tyson 450 (GA).
Washington. Blake 112 (FLAS).

Georgia: County unknown. Eggleston 5106, Albany (NY, US).
Baldwin. Pyron & McVaugh 1271 (GA, US). Ben Hill. Duncan
 14343 (GA). Decatur. Thorne 6586 (GA). Dougherty. McKellar
 29 June 1937 (GA); McKellar 30 June 1937 (GA). Macon. Pyron
 122 (GA). Richland. Cuthbert September 1897 (FLAS); Cuthbert
 September 1899 (FLAS, NY); Smith 21 September 1883 (NY, US).

Mississippi: County unknown. Tracy 4 September 1898,
 Bond Point (MO, NY, US). Harrison. Hood 430 (FLAS); Joor 23
 September 1891 (MO); Lloyd & Tracy 190 (NY); Pennell 4392
 (DUKE, NY); Smith 536 (US); Tracy 4 September 1901 (MO).
Jackson. Channell 1593 (FSU); Channell 1665 (DUKE); Demaree
 32731 (ISC); Demaree 33966 (FSU, ISC, OKLA); Demaree 34099
 (ISC); Kearney 6 October 1896 (US); Seymour & Seymour 91
 (DUKE); Seymour & Seymour 30 September 1891 (DUKE); Skehan 12
 September 1895 (MO, US). Pearl River. Isely & Wemple 9101
 (ISC); Sargent 7817 (OKLA). Perry. Demaree 36252 (FSU, OKLA).

Petalostemon compactum -- specimens examined

State unknown: Hall & Harbout 105 "American Plains"
 (NY, US).

Colorado: Adams. Kelso 363 (RM). Denver. Eastwood 34
 (US); Letterman 19 (ISC); Letterman 108 (NY); Letterman 241
 (US); Tracy 900 (NY); Ward 20 August 1881 (US). Jefferson.
 Kuntze 19 September 1874 (NY). Larimer. Crandall 26 August
 1898; Swezey 930 (ISC, NY, RM, US). Weld. Ewan 12284 (NO);
 Greene 20 July 1872 (NY); Johnston 817A (RM); Osterhout 29
 July 1899 (NY, RM); Osterhout 1059 (RM); Osterhout 2311 (NY,
 US); Osterhout 5149 (RM); Osterhout 7475 (RM).

Kansas: Grant. Thompson 26 (NY, US). Morton. Hulbert
 3232 (OKLA).

Nebraska: County unknown. Hapeman 4 August 1891 (RM).
Keith. Swezey 25 July 1890 (NY). Scotts Bluff. Rydberg 61
 (NY, US). Sioux. Miller 26 August 1901 (ISC).

New Mexico: County unknown. Cockerell 12, Rito de los

Frigoles (US). Bernalillo. Nelson 328 (RM); Vasey year 1881 (US). Dona Ana. Wootton 8 October 1912 (US). Sandoval. Arsen & Benedict 16488 (US); Ripley & Barneby 8347 (NY).

Oklahoma: Cimarron. Rogers 4762 (US); Rogers 6145 (TEX, US).

South Dakota: Fall River. Hayward 539 (NY).

Texas: Culberson. Warnock 9313 (SMU). Martin. Tharp 5969 (TEX, US). Mitchell. Pohl 4974 (ISC, SMU).

Wyoming: Platte. Nelson 2577 (RM); Nelson 8561 (RN).

Petalostemon decumbens -- specimens examined

Colorado: County unknown. Young 26 May 1916.

Oklahoma: Bryan. Taylor 726 (OKLA); Wemple & Jackson 579 (ISC). Choctaw. Wemple & Jackson 571, 586, 587, 590, 594, (ISC); Wemple 421, 422, 424, 428 (ISC); Ripley & Barneby 7427 (NY); Smith & Handel 66 (SMU); Waterfall 7570 (OKLA, TEX); Waterfall 1608 (OKLA). McCurtain. Houghton 3639 (NY); Reed 7 June 1950 (TEX, ISC, SMU); Waterfall 12427 (US, OKLA, SMU); Wemple & Jackson 599, 604, 605 (ISC); Waterfall 16983 (OKLA).

Texas: Brazoria. Stratton 820 (OKLA); Young 22 April 1918 (TEX). Harris. Palmer 9619 (US); Traverse 108 (SMU); Wemple & Jackson 731 (ISC). Liberty. Hooks 10 May 1940 (TEX, OKLA). Mata Gorda. Palmer 9731 (US); Walter 22 (TEX). Polk. Tharp et al. 54096 (OKLA, TEX, SMU). Red River. Adams 100a (SMU). Tyler. Tharp et al. 54833 (TEX, SMU); Wemple & Jackson 677 (ISC).

Petalostemon feayi -- specimens examined

Florida: County unknown. Curtiss 568 (GA, MO, NY); Hood 14 August 1910 (FLAS); Pammel 24 February 1928 (ISC); Tracy 6879 (MO, NY, US). Brevard. no collector listed 3 August 1929 (TENN). De Soto. Small & DeWinkeler 9771 (FLAS, DUKE). Franklin. Ford 3150 (US); Godfrey 52374 (DUKE); Godfrey 60267 (FSU); Godfrey et al 53463 (DUKE, FSU, NY); Jackson 423 (DUKE, FSU); Kral 2404 (FLAS); Kurz 1 November 1941 (FLAS); Sargent 23 June 1950 (GA). Hernando. Cooley & Ray 7013 (FSU); Hardin 296 (GA); Small et al (US). Highlands. Brass 15564 (FSU, US); Ford & Bennett 6 August 1960 (FLAS); Isely & Wemple 9316 (ISC); Isely & Wemple 9319 (ISC); Isely & Wemple 9330 (ISC); McFarlin 9376 (FLAS); Sargent (OKLA); Small & West 5 September 1934 (FLAS); Thorne 15245 (US); Webster 4209 (US). Hillsborough. Blanton 6691 (NO, US); Britton & Milson 2 (NY); Fredholm 6391 (ISC, MO, US); Garber May 1876 (FLAS); Lakela 23281 (FLAS). Indian River. Lemaire 169 (FSU). Lake Hitchcock 1104 (MO, NY); Murrill 17 July 1939 (FLAS); Nash 1523 (MO, NY, US); Nash 1524 (NY, US); Nash 1557 (DUKE); O'Neill 2 August 1920 (FSU, US); Turner 4673 (TEX); Wilbur & Webster 2658 (US). Manatee. Tracy 6337 (US). Marion. West & Arnold 16 September 1941 (FLAS); Kral 7676 (FSU, GA, NY); Murrill 680

(US); West 12 May 1933 (FLAS). Martin. Beck 24 October 1950 (FLAS); Small et al 10699 (TENN). Orange. Isely & Wemple 9315 (ISC); Lewton 10 August 1894 (NY); Weislahn 128a (US); Moldenke 5360 (NY). Pasco. Burger & West 16 September 1927 (FLAS). Polk. Bottimer 575 (GA); Correll 6328 (DUKE); Curtiss 5880 (FSU, GA, ISC, MO, NY, US); Godfrey & Kral 53841 (FSU); Kral (Louisiana Polytechnic Institute); Lakela 24582 (FLAS); McFarlin 907 (FLAS); Weber & Kelbert 7 August 1928 (FLAS); Wilbur & Webster 2631 (US). Putnam. Hume 8 August 1947 (GA); Wise 4 August 1940 (FLAS). Seminole. Schallert 5414 (OKLA). Volusia. Curtiss 6699 (GA, ISC, MO, NY, US); Hood 8 September 1913 (FLAS); Van Cleef 10 July 1937 (FLAS). Wakulla. Ford 4691 (FLAS); Godfrey 58818 (FSU).
Georgia: Liberty. Harper 1995 (MO, NY, US).

Petalostemon flavescens -- specimens examined

Arizona: Navajo. Peebles & Fulton 11939 (US).
Utah: County unknown. Jones 6223, Lower Crossing (NY, US).
Emery. Maguire 18421 (NY); Maguire 18481 (NY); Maguire et al 25 June 1933 (RM); Ripley & Barneby 8669 (NY). Garfield.
Harrison 11559 (ISC, US). Grand. Welsh & Moore 2004 (ISC).
San Juan. Barneby 13082 (NY); Holmgren & Goddard 9990 (NY);
Holmgren & Hansen 3431 (NY, SMU).

Petalostemon foliosum -- specimens examined

Illinois: County unknown. Beeb year 1880, Fountaindale (ISC). Kankakee. Hill year 1872 (US). Will. Umbach 5715 (ISC).
Tennessee: County unknown. Gattinger no date or number, "Middle Tennessee" (TENN). Davidson. Gattinger no date or number "Barrens around Nashville" (US); Gattinger year 1887 (NY); Gattinger July 1878 (NY, TENN, US); Gattinger 28 July 1878 (US); Gattinger July 1879 (NY); Gattinger 1 July 1881 (US); Gattinger July 1886 (US); Gattinger 570 (GA, US).
Franklin. Gattinger no date or number (NY). Knox. Lanher 20 September 1938 (TENN). Rutherford. Gattinger July 1886 (NY); Gattinger August 1886 (US); Sharp & Shanks 25455 (TENN); DeSelm 1879 (TENN); Isely & Wemple 9420 (ISC).

Petalostemon gattingeri -- specimens examined

Alabama: County unknown. Mohr 5 June 1892 (NY); Mohr 10 June 1892 (US). Franklin. James 20 May 1944 (US, NY); Sargent 6521 (SMU); Wemple 470 (ISU).
Georgia: Catoosa. Churchill 25 May 1011 (TENN); Duncan 12455 (US, FLAS, TENN, GA, SMU, DUKE, ISC). Walker. Duncan 12532 (SMU, GA); Duncan & Hardin 15925 (GA).
Tennessee: County unknown. Gattinger June 1879 (NY); Gattinger 565 (TENN). Bedford. Sharp 25923 (TENN). Davidson.

Gattinger year 1877 (TENN); Gattinger year 1878 (US, NY); Gattinger May 1882 (US); Gattinger year 1878 (NY, TENN); Gattinger year 1879 (US); Gattinger 565 (SMU, GA); Shanks 1513 (TENN); Sharp 1519 (TENN); Woodruff 10 June 1937 (TENN). Hamilton. Barnhart 2285 (NY). Maury. Sharp et al 5791 (TENN). Meigs. Deselm 2046 (TENN); Sharp & Hatcher 26932 (TENN); Sharp & Jones 28177 (TENN). Rutherford. Biltmore 5736 (US, NY); Demaree 45747 (ISC); Deselm 566 (TENN); Deselm 1504 (TENN); Deselm 1528 (TENN); Eggert 14 July 1897 (US, NY); Eggert 18 August 1897 (US, NY, ISC, TEX); Gattinger June 1886 (NY); Gattinger year 1886 (US); Hubric B2157 (TENN, OKLA); Isely & Wemple 9428 (ISC); McVaugh 4451 (GA); Quarterman 1664 (DUKE, TEX); Sharp & Clebsch 7583 (TENN); Sharp & Sharp 25903 (TENN); Sharp et al 7581 (TENN); Smith May 1881 (US); Svenson 219 (US); Wemple 472 (ISC); Wemple 473, 474 (ISC). Wilson. Deam 61914 (DUKE); Kriebel 9877 (SMU, DUKE); McVaugh 4416 (US, NY); Sharp 1577 (TENN); Sharp & Shanks 1562 (TENN); Wilson 28 May 1939 (TENN).

Petalostemon gracile -- specimens examined

Alabama: Baldwin. Harper 4162 (US); Isely & Wemple 9129 (ISC); Turner & Tharp (OKLA, SMU). Escambia. Ford 5532 (FLAS). Mobile. Graves 1256 (US); Isely & Wemple 9115 (ISC); Mohr August - September 1822 (NY); Mohr year 1878 (NY); Mohr 1 October 1886 (US); Mohr 1 October 1891 (US); Pennell 4450 (NY).

Florida: Bay. Hood 3284 (FLAS). Calhoun. Hood 2736 (FLAS). Gulf. Chapman, Apalach (NY); Chapman 3040 (MO, NY, US). Jackson. Hood 2610 (FLAS). Okaloosa. Isely & Wemple (ISC); West 27 September 1950 (FLAS). Santa Rosa. Ford 5392 (FLAS). Wakulla. Kral 5860 (FSU, SMU). Walton. Hood 3008 (FLAS); Hume 29 August 1938 (FLAS). Washington. Hood 2810 (FLAS); Isely & Wemple 9181 (ISC); Kral 3596 (FSU).

Georgia: Decatur. Thorne & Davidson 17112 (GA).

Louisiana: St. Tammany. Corbin 187 (SMU).

Mississippi: Harrison. Demaree 28327 (SMU). Jackson. Demaree 28327 (ISC); Demaree 34099c (ISC); Demaree 34202 (ISC, SMU); Hood 395 (FLAS); Isely & Wemple 9110 (ISC); Lloyd & Tracy 153 (NY); Oosting 1988 (DUKE); Seymour 146 (DUKE); Seymour & Earle 146 (DUKE); Seymour & Earle 146 (53) (SNU); Skehan 31 August 1895 (MO, US); Tracy 4844 (MO, NY, US).

Petalostemon griseum -- specimens examined

Louisiana: Bienville. Dormon year 1930 (NY).

Texas: County unknown. Bain 43 (FSU); White year 1912 (TEX). Anderson. Marsh U.56-26 (TEX). Angelina. Correll 12558 (FSU). Cherokee. Isely 5839 (ISC). Gregg. York year 1939 (TEX). Henderson. Harris 25 July 1927 (TEX). Houston. LaSueru & Smith 7 July 1935 (OKLA, TEX); Tharp 817 (NY). Milam. Tharp 15 June 1932 (OKLA, TEX); Tharp 4 June 1939 (TEX).

Montgomery. Turner 3892 (DUKE, RM, TEX). Nacogdoches. Turner 4572 (TEX). Polk. Tharp et al 54869 (TEX). Robertson. Tharp et al 541025 (OKLA). Smith. Cory 59111 (OKLA). Upsure. Wemple 434 (ISC). Van Zandt. VanVleet 1531 (TEX). Wood. McMullen 20 June 1927 (TEX); Reverchon 1949 (US, NY).

Petalostemon microphyllum -- specimens examined

Oklahoma: Marshall. Goodman 6152 (NY, OKLA, SMU); Goodman 6705 (OKLA); Wemple & Jackson 553 (ISC).
Texas: County unknown. Hall year 1872 (US); Thurow year 1894 (US); Vallum 3 June 1855 (US). Aransas. Jones 889 (SMU); Tharp year 1932 (TEX); Tharp 2 July 1939 (NY, TEX); Turner 3971 (TEX). Austin. Wemple & Jackson 725 (ISC). Bastrop. Tharp 19 June 1939 (OKLA, TEX). Brazos. Parks 21 June 1947 (SMU). Caldwell. MacBride 12 June 1931 (TEX); Ochendon 31 May 1964 (ISC). Callahan. Wemple 249 (ISC). Dallas. LeRoy no date or location (NY); Orr 52 (SMU); Reverchon June (NY); Reverchon July 1876 (NY); Reverchon 233 (US); Reverchon June 1881 (US); Reverchon 233 (NY); Reverchon 1949 (NY, SMU, US). Freestone. Lenell 12964 (US); Wemple & Jackson 631, 635 (ISC). Goliad. Williams 167 (TEX). Grimes. Tharp & Tyson 27 June 1952 (OKLA, TEX). Gonzales. Bogusch 2040 (TEX); Hopkins 9 July 1889 (US). Harris. Boon 50 (TEX); Thurow 26 (US); Traverse 773 (SMU, TEX); Wemple & Jackson 705 (ISC). Hays. Stanfield, San Marcos and vicinity (NY). Henderson. Shinnors 15098 (SMU, TEX); Wemple 447 (ISC). Hood. Shinnors 10343 (SMU, TEX, US); Waples School July 1927 (TEX). Houston. Tharp 8 June 1920 (US). Lee. Kublock 17 June 1931 (TEX). Leon. Wemple & Jackson 646 (ISC). Milam. Tharp (OKLA, TEX). Montgomery. Thurow 3 (US). Montague. Whithouse 10057 (SMU). Nueces. Tharp 1 July 1939 (FSU, TEX). Palo Pinto. Shinnors 10295 (SMU). Parker. Shinnors 24086 (OKLA, SMU); Wemple 245 (ISC). Robertson. Jennings 114 (TEX); Walker 21 (OKLA, TENN, TEX); Wolff 1049 (US). Shelby. Cory 56525 (SMU). Tarrant. Ruth 1613 (TENN). Taylor. Henderson 62-733 (FSU). Van Zandt. Van Vleet 577 (SMU); Van Vleet 1616 (SMU, TEX); Wemple & Jackson 620 (ISC). Waller. Hall (NY, US). Young. Shinnors 12553 (SMU).

Petalostemon multiflorum -- representative specimens examined

MEXICO

Coahuila: Marsh 30, Muzquiz (OKLA, TEX); Wynd & Mueller 223, Muzquiz (NY, US).

UNITED STATES

Kansas: Bourbon. Bartley 1207 (NY, US); Chase, Stevens no number or date (US); Chautauqua. McGregor 15040 (SMU); Cowley. White June 1898 (NY); Geary. Gayle 573 (NY); Green-

wood, Hall August 1870 (NY); Miami, Oyster August 1882 (ISC); Pottawatomie, Crevecoeur 1 (US); Pratt, Smyth 104 (NY, US); Riley, Norton 96 (NY, RM, US); Sedgwick, Bartley 1126 (NY).

Missouri: Jackson, Bush 826 (NY, US).

Oklahoma: Atoka, Howard 28 (TEX); Bryan, Blain 70 (US);

Canadian, Waterfall 1527 (NY); Carter, Wemple 401 (ISC); Choctaw, Waterfall 12431 (OKLA); Comanche, Kaeiser 28 (NY); Cotton, Wemple 396 (ISC); Jefferson, Wemple 399 (ISC); Kay, Davy 96 (OKLA); Kiowa, Barnes 19 July 1947 (OKLA, TEX);

Lincoln, VanVleet 15 July 1905 (US); Marshall, Wemple 404 (ISC); McClain, Demaree 13183 (NY); Murray, Demaree 13193 (GA, NY, OKLA, SMU, TEX, US); Osage, Sizemore 269 (OKLA);

Payne, Renfro 147 (TEX); Pontotoc, McCoy 1743 (OKLA); Seminole, Hopkins & Demaree 47 (OKLA); Tillman, Wemple 395 (ISC); Tulsa, Clark 488 (OKLA).

Texas: Austin, Wurzlow 30 (US); Bastrop, Tharp 10 June 1939 (TEX); Bee, Wemple & Jackson 762 (ISC); Bell, York & York 54562 (SMU, TEX); Bexar, Groth 144 (ISC, NY, US); Bosque, Whitehouse 21 July 1929 (TEX); Brazos, Reverchon 1948 (SMU, US); Brown, Henderson 62-850 (ISC); Burnet, Schaupp 3 August 1892 (US); Caldwell, Tharp & Tyson 52-537 (ISC, TEX); Calhoun, Tharp 22 May 1930 (OKLA, TEX); Callahan, Warnock 46359 (TEX); Clay, Shinnors 15230 (SMU); Comal, Lewton 746 (FSU); Cooke, Correll & Correll 12959 (FSU, SMU); Coryell, Muller 8734 (SMU); Crockett, Tharp 6405 (OKLA, TEX); Dallas, Reverchon 1947A (NY, SMU, US); Denton, Dobbins 1 (SMU); De Witt, Riedel 3 June 1942 (TEX); Duval, Croft 175 (NY); Ellis, Cory 53338 (SMU); Erath, Cory 58070 (OKLA, SMU); Fayette, Tharp 2345 (OKLA, TEX, US); Galveston, Turner 3067 (OKLA, TEX); Gillespie, Jermy 752 (US); Goliad, Wemple & Jackson 773 (ISC); Grayson, Hennen 223 (ISC, SMU); Grimes, Turner & Tharp 3076 (OKLA, TEX); Harris, Traverse 146 (SMU); Hays, Stanfield summer 1897 (NY); Hood, Wemple 242 (ISC); Jackson, Drushel 8799 (NY, US); Johnson, Lamb 17 July 1937 (SMU); Jones, Adams 3 (SMU); Karnes, Johnson 992 (TEX); Kendall, Parks 43102 (TEX); Kerr, Heller year 1903 (NY, US); Matagorda, Palmer 9732 (US); McCulloch, Gould 5689 (SMU, TEX); McLennan, Smith 930 (TEX); Montague, Whitehouse 10503 (SMU); Navarro, Bryant 13 (SMU); Nueces, Heller 1814 (ISC, NY, RM, SMU, US); Rockwall, Cory 53312 (RM, SMU, US); Runnels, Gould 7074 (SMU, TEX); San Patricio, Wemple & Jackson 753 (ISC); Schleicher, Reed 255 (FSU); Sutton, Reed 258 (FSU); Tarrant, Ruth 28 (ISC, NY, RM, SMU, TENN, US); Taylor, 7443 (ISC, NY, TEX); Travis, Johnson & Barkley 6055 (SMU, TEX); Val Verde, Palmer 13585 (US); Walker, Dixon 378 (NY); Waller, Hall 138 (NY, US); Washington, Brackett 128 (TEX); Williamson, York & York 55189 (SMU, TEX); Wise, Shinnors 24084 (ISC, OKLA, SMU).

Petalostemon obovatum -- specimens examined

Texas: County unknown. Berlandier 2202 (NY); Berlandier 2494, San Patricio to Goliad (US); LeRoy no date or number (NY); Lindheimer no date or number (NY); Lindheimer 40 (US). Aransas. Johnston 10 June 1953 (TEX); Wemple & Jackson 739 (ISC). Atascosa. Palmer 9788 (US). Austin. Wemple & Jackson 724 (ISC). Bexar. Palmer 230 (NY, US); Schulz 2378 (US). Brooks. Johnston 541202 (TEX); Johnston 54491 (TEX); Runyon 2630 (US). Cameron. Shiller 183 (US). Colorado. Bedicheck 21 June 1945 (TEX); Tharp 2343 (TEX, US). DeWitt. Riedel 5 July 1941 (TEX); Webster & Wilbur 3016 (US). Gonzales. Bogusch 929 (TEX, US). Guadalupe. Webster & Rowell 7090 (TEX); Wolcott & Barkley 16 T 437 (TEX). Jackson. Drushel 8923 (NY). Karnes. Johnson 907 (TEX); Johnson 1626 (TEX). Kenedy. Fisher 41185 (US); Johnston 54572 (TEX); Runyon 4332 (FSU, TEX, US); Tharp 47430 (TEX). Kleberg. Johnston 4 July 1953 (TEX); Johnston 54437 (OKLA, TEX). Lavaca. Tharp et al 49170 (OKLA, TEX, US). Medina. Johnston et al 3435 (TEX). Nueces. Tharp & York 51-107 (OKLA, TEX); Turner 3962 (TEX). Travis. Tharp 2 July 1921 (TEX). Val Verde. Tharp 8 July 1928 (TEX). Willacy. Tharp 5 March 1934 (TEX). Wilson. Cory 15070 (TEX); Johnston 2540 (TEX); Parks 2420 (TEX); Rogers et al 6861 (OKLA, TEX); Sullivan & Turner 10 (TEX); Wemple 225 (ISC).

Petalostemon occidentale -- representative specimens examinedCANADA

Alberta: Moodie 60, vicinity of Calgary (NY); Moodie 1147, vicinity of Rosedale (NY); Mcss 287, N of Pincher (US); Rusby 29 July 1915, near Medicine Hat (NY).

Manitoba: Bolvin & Dore 7740, Brandon (NY).

Saskatchewan: Bird 1274, W of Val Marie Reservoir (OKLA); Ledingham 1184, SW of Boharm (ISC, NY); Macoun July 1880, Moose Jaw (NY).

MEXICO

Chihuahua: Goldman 420, Casas Grandes (US); Mexia 2621, between Calera and Basuchil (NY, US); Pringle 1216, near Guerrero (NY, US); Shreve 7971, N of Rubio (US).

UNITED STATES

Arizona: Apache, Peebles 12460 (US); Cochise, Gooding 2350 (RM); Coconino, MacDougal 260 (ISC, NY, RM, US); Graham, Fosberg 53387 (NY); Navajo, Pultz 1672 (NY); Santa Cruz, Peebles 5329 (US); Yavapai, Peebles et al 4254 (US).

Colorado: Boulder, Tweedy 5267 (NY, RM); Denver, Eastwood 35 (US); Douglas, Livingston 294 (DUKE); El Paso, Livingston 496 (DUKE, TEX); Fremont, Shear 3443 (NY, US); Huerfano, Vreeland 632 (NY); Larimer, Crandall 2 July 1892

(NY); Las Animas, Rollins 1870 (NY, RM, US); Lincoln, Ownbey 1344 (NY, RM); Pueblo, Ripley and Barneby 7644 (NY); Weld, Osterhout 2366 (NY, RM); Yuma, Iltis and Iltis 19271 (ISC).

Iowa: Harrison, Morrill 905 (ISC); Monona, Morrill 912 (ISC); Plymouth, Thorne 14670 (FLAS, NY, SMU); Woodbury, Pammel 13 (FLAS, ISC, NY, US).

Kansas: Barber, McGregor 14443 (SMU, US); Clark, Welsh 671 (ISC); Comanche, White 9 September 1898 (US); Ellis, Bondy 225 (FLAS, RM); Grant, Thompson 40 (US); Gray, Wemple 309 (ISC); Hamilton, Rose 17042 (NY, US); Harper, Rydberg & Imler 619 (NY); Kearney, Wemple 313 (ISC); Kiowa, Ward 19 September 1897 (NY); Meade, Horr 3520 (DUKE, FLAS, OKLA, SMU, TEX, US); Norton, Smyth 333 (NY); Osborne, Shear 138 (RM, US); Phillips, Harshbarger 4 August 1892 (US); Pratt, Hulbert 3195 (OKLA); Sherman, Harshbarger 1 August 1892 (US); Stevens, Wemple 326 (ISC); Trego, Horr & Horr 4164 (NY); Wallace, Redfield 16 July 1872 (NY).

Minnesota: Big Stone, Pammel 2 September 1920 (ISC).

Montana: Carbon, Wilcox 402 (NY); Cascade, Blankinship 680 (RM, US); Custer, Crider & Atkins 30 (RM); Dawson, Arton June and July 1892 (NY); Park, Scheuber 1 August 1901 (ISC, NY, US); Powder River, Barneby 13231 (NY); Sheridan, Larsen 216 (NY, SMU, US); Sweetgrass, Hitchcock & Muhlick 13311 (NY, RM); Wheatland, Wooten 21 July 1921 (US); Yellowstone, Hunt 20 July 1902 (ISC).

Nebraska: Brown, Rutter June 1893 (US); Chase, Tolstead 411021 (ISC); Dawes, Welsh 729 (ISC); Deuel, Rydberg 25 June 1891 (NY, RM, US); Dundy, Isely 8175 (ISC); Garfield, Iltis 18563 (ISC); Hooker, Rydberg 1480 (NY); Kearney, Hapeman 21 July 1928 (NY); Kimball, Kiener 28646 (US); Knox, Clements 2699 (ISC); Scotts Bluff, Rydberg 8 July 1891 (US); Sheridan, Buchanan 2--20 August 1905 (ISC); Sioux, Tolstead 13 July 1940 (ISC); Valley, Davidson et al 4691 (TEX).

New Mexico: Bernalillo, Kuntze 23203 (NY); Catron, Eggleston 20336 (RM, US); Chaves, Earle & Earle 30 August 1900 (NY); Curry, Shinnars 20875 (SMU); Dona Ana, Wooten 122 (NY, RM, US); Grant, Metcalf 121 (NY, RM, US); Guadalupe, Rose 17657 (NY, US); Lincoln, Wooten 250 (NY, RM, US); McKinley, Ripley & Barneby 7060 (NY); Otero, Waterfall 12463 (OKLA); Quay, Fisher 178 (US); Rio Arriba, Eggleston 20565 (NY); Sandoval, Preece & Turner 2748 (SMU); San Juan, Wooten 8 August 1904 (US); San Miguel, Standley 4955 (NY, US); Santa Fe, Heller & Heller 3827 (NY, US); Sierra, Metcalf 1151 (NY, US); Socorro, Wooten 5 August 1900 (US); Valencia, Rusby 16 July 1880 (US).

North Dakota: Benson, Welsh 777 (ISC); Billings, Seymour 2 September 1884 (DUKE); Bottineau, unknown 19 August 1891 (NY); Burleigh, Lunell 23 August 1913 (US); Grant, Bell 1177 (RM); Morton, Sarvis 146 (US); Pembina, Bergman 2269 (RM); Slope, Moyer 716 (NY); Stark, Stevens 1554 (US); Ward,

Waldron 1834 (RM).

Oklahoma: Beckham, Welsh 692 (ISC); Blaine, Waterfall 8122 (OKLA); Bryan, Blain 77 (US); Caddo, Demaree 13067 (NY, SMU); Cimarron, Rogers 4673 (US); Cleveland, Demaree 13185 (DUKE, NY, SMU, TEX, US); Comanche, Stevens 1359 (OKLA); Creek, Fry 79 (OKLA); Custer, Waterfall 1508 (OKLA); Ellis, Welsh 686 (ISC); Greer, Stevens 998 (NY, OKLA, US); Harmon, Waterfall 8338 (OKLA, SMU); Harper, Welsh 680 (ISC); Kingfisher, Blankinship 1 June 1896 (RM, US); Lincoln, Van Vleet 15 July 1905 (ISC); Major, Waterfall 8143 (OKLA); McClain, Demaree 13185 (DUKE, SMU, TENN, TEX); Noble, Harding 372 (OKLA); Oklahoma, Waterfall 2225 (OKLA); Payne, Ikenberry 38 (TEX); Roger Mills, Welsh 689 (ISC); Texas, Butler 120 (OKLA).

South Dakota: Brule, Isely 6034 (ISC, US); Clark, Williams August 1891 (US); Custer, Hayward 2559 (RM); Deuel, Isely 8125 (ISC); Fall River, Welsh 744 (ISC); Grant, Pammel 31 July 1918 (ISC); Harding, Visher 232 (RM); Lawrence, Carr 92 (NY, RM); Meade, Forwood 71 (US); Mellette, Tolstead 4-201 (ISC); Potter, Griffiths 257 (US); Todd, Tolstead 4-435 (ISC).

Texas: Bailey, Ferris & Duncan 3434 (NY); Brewster, Warnock 323 (SMU, TEX, US); Briscoe, Whitehouse 10004 (SMU); Collingsworth, Wemple 381 (ISC); Childress, Childress High School Bio. Class 27 June 1931 (TEX); Culberson, Moore & Steyermark 3604 (NY, US); Dallam, Wemple 339 (ISC); Garza, Reed 3564 (US); Gray, Wemple 371 (ISC); Hall, Reverchon 3750 (SMU, US); Hartley, Palmer 14125 (US); Hemphill, Tharp & Miller 51-1-171 (TEX); Hutchinson, Cory 50343 (SMU); Jeff Davis, Cory 53102 (SMU, US); Lipscomb, Wallis 5100 (OKLA, SMU); Lubbock, Reed 4183 (RM, SMU); Mitchell, Pohl 4953 (ISC, SMU); Nolan, Palmer 13719 (US); Ochiltree, Wallis 4838 (OKLA, SMU); Oldham, Reverchon 3005 (SMU, TEX); Potter, Wemple 359 (ISC); Presidio, Hinckley 660 (NY, TEX); Randall, Cory 50437 (NY, SMU, US); Reeves, Henderson 62-639 (FSU); Roberts, Wallis 4942 (OKLA, SMU); Stonewall, Tharp & Gimbrede 51-998 (TEX); Swisher, Wemple 254 (ISC); Terry, Tharp 10 July 1941 (TEX); Wichita, Whitehouse 9889 (GA, SMU).

Utah: Emery, Harrison 9805 (ISC, US); Garfield, Maguire 7400A (NY); Grand, Purpus 6495 (US); San Juan, Holmgren 3789 (NY, US); Wayne, Maguire 19299 (NY).

Wyoming: Albany, Nelson 7378 (ISC, NY, RM, US); Big Horn, Moore & Moore 4 July 1896 (RM); Campbell, Porter and Porter 7576 (RM); Converse, Porter 3152 (RM, US); Crook, Ownbey 471 (RM); Goshen, Brenckle & Petrak 50085 (NY); Laramie, Williams 2537 (US); Natrona, Goodding 204 (ISC, NY, RM, TENN, US); Niobrara, Isely 6526 (ISC); Weston, Degener & Peiler 16014 (NY).

Petalostemon ornatum -- specimens examined

Idaho: Canyon. Christ & Christ 16734 (NY); Tucker 577 (NY). Elmore. Christ 11142 (NY); Christ & Christ 17896 (NY); Nelson & MacBride 1136 (NY, RM, US). Owyhee. Beath 18 May 1938 (RM); Christ 9562 (NY); Hitchcock & Muhlick 21984 (NY); Maguire and Holmgren 26229 (NY, US); Ripley & Barneby 6146 (NY).
 Nevada: Lyon. Alexander & Kellogg 5306 (ISC).
 Oregon: County unknown. Leiberg 2245, Mathew Valley near Harbor Ranch, (NY). Harney. Train 18 June year unknown (TENN).
Lake. Tidestrom 3588 (US); Eggleston 6891 (NY, US). Malheur. Cusick 1229 (NY, US); Cusiek 1952 (US); Peck 21222 (NY).
Morrow. Cronquist 6499 (NY, TEX, US); Peck 17425 (NY). Sherman. Baker 845 (RM); Howell 8 May 1885 (NY, US); Lawrence 344 (US). Umatilla. Dana 28 June 1933 (OKLA); Jones 25373 (US).
Wheeler. Chisaki & Tavares 789 (RM); Clarkson 22 July 1953 (ISC); Cronquist 7246 (NY); Lawrence 1029 (US); Marks 22 July 1953 (ISC); Peck 10087 (NY); Peck 18640 (NY).
 Washington: County unknown. Brandege & Tweedy 714, near Columbia and Snake Rivers (NY). Benton. Hitchcock & Muhlick 22593 (RM); Rose 48155 (ISC, NY); St. John & Mullen 8645 (NO). Franklin. D'Ewart summer 1949 (NY); Leckenby 14 June 1898 (US). Whitman. Hitchcock & Muhlick 21851 (ISC, NY); Ownbey & Ownbey 2056 (FLAS, ISC, NY); St. John & Warren 3095 (NY). Yakima. Thompson 9256 (NY, RM, US). Walla Walla. Tweedy 637 (US); Wilkes, no number or date (US).

Petalostemon phleoides -- specimens examined

Texas: County unknown. Thurow year 1894 (US); Whitehouse 15 July 1929, Manor-Brenham (TEX). Austin. Wurzlów 36 (US). Bee. Jones 1460 (FSU). Caldwell. J. B. M. (OKLA, TEX). Chambers. Fisher 294 (US). De Witt. Riedel 20 July 1941 (TEX). Dimmit. Johnson et al 3515 (TEX); Reed 261 (FSU). Hardin. Cory 56626 (SMU). Harris. Thurow 3 (US). Karnes. Johnson 53-377 (TEX). Leon. Wemple & Jackson 642 (ISC). Montgomery. Turner 3891 (DUKE, RM, SMU, TEX). Morris. Shinnors 18969 (SMU, TEX); Wemple & Jackson 618 (ISC). Folk. Wemple & Jackson 666 (ISC). Trinity. Turner 4576 (TEX); Wemple & Jackson 660 (ISC). Upsure. Reverchon 2667 (NY, SMU). Walker. Fisher 23 June 1938 (ISC, SMU); Steyermark 38089 (RM); Tharp 637 (TEX, US). Weller. Hall year 1872 (US). Wilson. Cory 15076 (TEX).

Petalostemon pulcherrimum -- specimens examined

New Mexico: Socorro. Plank 20 August 1895 (NY).
 Oklahoma: Bryan. Wemple & Jackson 566, 566b (ISC).
Marshall. Easley 108 (RM); Wemple 402, 403, 406 (ISC).
Choctaw. Wemple & Jackson 573 (ISC).

Texas: County unknown. Drummond 129 (US); Wright 117 (US). Bell. York & York 54352 (SMU, TEX). Bexar. Clemens 653 (NY, RM); Schultz 158 (US). Blanco. Palmer 12173 (NY, US). Brown. Henderson 62-849 (FSU). Clay. Whitehouse 10041 (SMU). Collin. Whitehouse 10429 (SMU). Colorado. Hynes 22 (US). Comal. Lewton 751 (FSU); Rauterberg 1431 (SMU). Cooke. Correll & Correll 12951 (FSU, SMU); Gould 6866 (SMU, TEX). Coryell. Henderson 63-1011 (ISC). Dallas. Isely 4829 (ISC, OKLA, US); Isely 4811 (ISC); Lundell & Lundell 7052 (NY, SMU); Lundell & Lundell 9204 (US); Orr 44 (SMU); Sanders 168 (SMU); VanVleet 193 (SMU); Walden 25 (SMU); Wemple 247 (ISC). Denton. Dobbins 2 (SMU); McCart 259 (SMU). DeWitt. Riedel 3 June 1942 (TEX). Eastland. collector not indicated, Ranger, April 1935 (TEX); Collector not indicated, Hodge Oak Pk. School, April 1935 (OKLA). Ellis. Cory 53336 (SMU). Fannin. Tharp 47349 (TEX). Fayette. Hipple 51-725 (TEX); Tharp 2344 (TEX, US). Gillespie. Jermy 666 (US); Palmer 10051 (US). Goliad. Johnston 541231 (TEX). Grayson. Sumanth 64 (OKLA). Gregg. Letterman August 1881 (ISC). Grimes. Wemple & Jackson 717 (ISC). Hayes. Stanfield, San Marcos (NY); Warnock 46466 (TEX). Hudspeth. Warnock 4000, 5931 (SMU, TEX). Jackson. Drushel 4 June 1933 (NY); Drushel 9567 (TEX). Johnson. Whitehouse 15 June 1930 (TEX). Kaufman. Hennen 441 (SMU); Loving 12 June 1949 (OKLA, TEX). Kendall. Cory 45154 (TEX); Parks 43103 (TEX); Reed 264 (FSU). Kerr. Heller 1857 (ISC, IKLA, RM, SMU, TEX, US). McLennan. Mauldin 23 June 1946 (SMU); Shinners 14965 (SMU); Smith 619 (OKLA, TEX); Smith 673 (TEX); Smith 703 (TEX); York 46154 (TEX). Montague. Satterfield 3 (NY, SMU); Whitehouse 10098 (SMU). Montgomery. Gould & McCully 5774 (SMU, TEX); Wemple & Jackson 714, 716 (ISC). Navarro. Bryant 7 (SMU). Parker. Tracy 8041 (NY, SMU, TEX, US). Hockwall. Cory 53308 (RM, SMU, US). Tarrant. Cory 53257 (SMU, US); Cory 54460 (GA, SMU); Killian 6995 (TEX, US); McCart 100 (SMU); Palmer 14233 (US); Reverchon 2666 (NY); Ruth 24 (ISC, SMU, TENN, RM, NY, US); Ruth 57 (TEX); Ruth 1218 (SMU); Whitehouse 16072 (GA, SMU, US). Travis. Albers 47123 (TEX); Tharp 43-445 (TEX); Tharp 44206 (ISC, TEX); Young 4 July 1912 (TEX); Young 24 May 1912 (TEX). Walker. Dixon 379 (NY). Williamson. Reese 25 September 1938 (TEX); Reese 27 May 1939 (SMU, TEX); Wemple 234 (ISC).
Tennessee: Knox. Underwood, U.T.FARM 794 (TENN).

Petalostemon purpureum -- representative specimens examined

CANADA

Alberta: Andersson 4, Calgary (NY); Breitung 17754, Waterton Lakes National Park (NY, SMU); Degener 18316, Cordston (NY); Moodie 18 July 1913, Elbow River Valley (US); Moodie 1149, Rosedale (NY); Moss 61, W of Pincher Creek (US); Pammel 6 August 1909 (ISC); Busby 29 August 1915 (NY); Turner 17, Ft. Saskatchewan (NY).

Manitoba: Bird 118, E. of Deloraine (OKLA); Degener 959, McGregor (NY); Dore & Breitung 12655, NE of Melita (NY); Dudley, Birtle (OKLA); Fowler 7 July 1887, Brandon (US); Love & Love 5661, Langruth (US); Love & Love 6219, Indian Reserve 2A (US); Morris July 1894, Rosser (US).

Ontario: Denike 585, Ingolf (NY).

Saskatchewan: Bird 1326, MW Val Marie (OKLA); Bird 1404, W of Eastland (OKLA); Herriot 31 July 1906, Bare Hills (US); Johnson 30 July 1904, Assinibois (US); Johnson 936, Moose Jaw (NY); Ledingham 1185, SW of Boharm (NY); Ledingham 1355, N of Moose Jaw (ISC, TEX); Ledingham & Yip 11 August 1956, SE of Hirsch (ISC); Ledingham et al 2283, W of Caron (ISC); Macoun 17 July 1880, Moose Jaw (NY, US); Macoun & Herriot 70770, Grand Trunk Pacific RR (NY).

UNITED STATES

Alabama: Colbert, Isely 3742 (ISC); Greene, Sargent 16 June 1950 (GA); Hale, Mohr 25 May 1893 (US); Marengo, Harper 3385 (NY, US); Sumter, Shinnars 12634 (SMU).

Arizona: Yavapai, Peebles et al 4253 (US).

Arkansas: Baxter, Palmer 5950 (US); Benton, Demaree 6856 (SMU, TENN); Boone, Demaree 3218 (SMU); Clark, Demaree 17800 (ISC, SMU); Fulton, Demaree 26887 (ISC, SMU, TEX); Hempstead, Palmer 8036 (US); Howard, Iltis et al 5141 (US); Marion, Demaree 29102 (ISC, SMU, TEX); Newton, Demaree 22236 (NY, SMU); Pulaski, Hasse 5 September 1886 (NY); Randolph, Demaree 29210 (DUKE, ISC, OKLA, SMU, TEX); Stone, Demaree 23484 (NO, NY, SMU); Washington, Turner summer 1939-1940 (TEX).

Colorado: Denver, Eastwood 36 (US); Boulder, Welsh & Charette 1378 (ISC); Chaffee, Waterfall 11514 (OKLA); El Paso, Livingstone 389 (DUKE); Huerfano, McAllister 31 August 1923 (TEX); Jefferson, Isely 8659 (ISC); Larimer, Crandall 24 July 1895 (NY); Las Animas, Rogers 4589 (US); Logan, Osterhout 12 August 1897 (NY); Weld, Osterhout 371 (RM); Yuma, Osterhout 4073 (RM).

Idaho: Allen no location or date (NY).

Illinois: Adams, Wehmeyer 22 (GA, NY); Champaign, Storm 11 July 1948 (SMU); Coles, Pepon & Barrett 522 (US); Cook, Fawcett 1 September 1903 (ISC); Dupage, Ward 31 August 1893 (US); Henderson, Patterson July 1874 (NY); Kane, Eldredge 23 July 1888 (ISC); Kendall, Umbach 22 July 1897 (US); Lake, Gates 17252 (US); Madison, Sargent 27 June 1932 (TENN); Mason, Gleason 9216 (NY); Peoria, Chase 8332 (GA, ISC); Platt, Seymour 9 August 1886 (US); St. Clair, Eggert 5 July 1875 (ISC, NY); Stark, Chase 9 July 1896 (RM); Winnebago, Fell & Fell F 53-1046 (NY).

Indiana: Benton, Kriebel 5541 (SMU); Boone, Hale July 1838 (US); Cass, Friesner 9413 (OKLA, TEX); Jasper, Welsh 15606 (SMU); Knox, Tryon 3228 (DUKE); Lake, Dean 2413 (NY); Newton, Friesner 22382 (SMU); Tippecanoe, Miller & Milstead

151 (DUKE); Vigo, Evermann July 1889 (US).

Iowa: Allamakee, Schultz 80 (OKLA); Appanoose, Fitzpatrick & Fitzpatrick 11 July 1896 (NY); Boone, Isely (OKLA, US); Clayton, Shimek 29 July 1919 (NY); Dickinson, Thorne 12995 (US); Emmett, Cratty July 1895 (ISC, US); Fayette, Fink 223 (US); Fremont, Morrill 999 (FSU); Greene, Isely 5760 (ISC, OKLA); Jasper, Russell 74552 (TENN); Johnson, Shimek 3 July 1911 (FSU); Lucas, Bruggen 2701 (SNU); Lyon, Isely 5977 (ISC, SMU); Muscatine, Shimek 17 August 1926 (NY); Osceola, Shimek 14 September 1921 (FSU); Palo Alto, Hayden 4038 (GA, NY, SMU, US); Story, Pammel & Ball 12 (FLAS, ISC, NY, US); Union, Fay 3161 (US); Warren, Bruggen 1252 (FLAS); Webster, Isely 5888 (ISC, SMU); Winneshiek, Shimek 3 August 1919 (SMU); Worth, Wallis 21 August 1950 (OKLA).

Kansas: Anderson, Hulbert 3797 (OKLA); Barber, McGregor 14447 (SMU, US); Clark, White 14 September 1898 (US); Cowley, White June 1898 (NY); Douglas, Horr E89 (DUKE, FLAS, GA, ISC, NO, OKLA, SMU, TEX, US); Ellis, Bondy 226 (FLAS); Ford, McGregor 15767 (SMU); Geary, Wemple 296 (ISC); Greenwood, Ripley & Barneby 7252 (NY); Labette, McGregor 16987 (SMU); Marion, Horr 3478 (TEX, US); Osborne, Shear 135 (US); Pottawatomie, Marsh 1745 (SMU); Pratt, Wemple 306 (ISC); Reno, Smyth 35 (US); Riley, Norton 93 (NY, US); Russell, Jackson 95 (SMU); Sedgewick, Andrews 82 (ISC); Woodson, Lathrop 1418 (US).

Kentucky: County unknown, Pease 565, New York (KY); Nelson, Wharton 5575 (KY, NY).

Louisiana: Caddo, Dormon June 1930 (NY); LaSalle, Shinnars (ISC, SMU, TEX); Natchitoches, Ware 24 June 1956 (SMU, TEX).

Minnesota: Anoka, Jukkola 114 (TENN); Becker, Grant 13 August 1929 (NY, US); Benton, Moore & Huff 18791 (OKLA); Brown, Isely 8160 (ISC); Chippewa, Moyer 8 August 1897 (NY); Crow Wing, Sandberg 867 (ISC); Hennepin, Pammel 29 August 1903 (ISC); Kittson, Johnson 478 (ISC, NY); Lyon, Isely 8135 (ISC); Nicollet, Ballard July 1892 (NY); Norman, Bormann 111 (DUKE); Otter Tail, Sheldon August 1892 (TENN); Pennington, Moyle 1316 (NY); Ramsey, Gmelin July 1875 (ISC); Redwood, Isely 8149 (ISC); Rice, Pammel 22 July 1922 (ISC); St. Louis, Lakela 2666 (SMU); Stearns, Omelin August 1875 (ISC); Stevens, Pammel 4 August 1922 (ISC); Todd, Hotchkiss & Jones 4133 (US); Winona, Hasse 24 July 1892 (NY).

Mississippi: Lee, McDougall 1701 (US).

Missouri: Barry, Redfearn 10226 (FSU); Boone, Dickson 16 July 1927 (DUKE); Cass, Bush 12209 (DUKE); Franklin, Mason 71 (TEX); Greene, Redfearn 3731 (FSU); Jackson, Bush 3095 (NY); Jasper, Demaree 39313 (ISC, SMU); Livingston, Sparling 1109 (ISC); Mercer, Palmer & Steyermark 41289 (NY); McDonald, Bush 74 (NY); Morgan, Bush 137004 (TEX); St. Louis, Letterman 21 (ISC); Shannon, Redfearn 10050 (FSU); Stone, Palmer 5872 (US); Sullivan, Gleason 9253 (NY); Wright,

Lansing 5-12 June 1911 (US).

Montana: Carbon, Hitchcock 16582 (NY); Cascade, Blankinship 679 (US); Dawson, Ward 15 July 1883 (US); Lewis & Clark, Muth 11 August 1892 (NY); Park, Scheyber 25 July 1901 (ISC); Ponderosa, Brenckle & Shinnars 41096 (NY); Stillwater, Hitchcock 16559 (NY); Sweetgrass, Hitchcock & Muhlick 13297 (NY); Teton, Hermann 12343 (US); Toole, Cratty 27 August 1915 (ISC); Wheatland, Wooten 21 July 1921 (US); Yellowstone, Hood 1183 (FLAS).

Nebraska: Banner, Hydberg 59 (NY); Cherry, Isely 6520 (ISC); Custer, Webber 6 July 1889 (US); Dawes, Welsh 734 (ISC); Dawson, Mohl 22 July (ISC); Deuel, Hydberg 59 (NY); Gage, Washburn 2 July 1899 (US); Holt, DeLisle 447 (ISC); Hooker, Wemple & Wemple 798 (ISC); Kearney, Hapeman 4 July 1934 (SMU); Kieth, Welsh 710 (ISC); Lancaster, collector unknown 426 (TEX); Lincoln, Pammel 11 August 1923 (ISC); McPherson, Wemple & Wemple 795 (ISC); Red Willow, Wemple & Wemple 787 (ISC); Sheridan, Buchanan 2-20 August 1905 (ISC); Thomas, Blumer Sept-Oct 1902 (ISC); Valley, Davidson et al 10 July 1949 (TEX).

New Mexico: Colfax, Mahler 866 (NY); Mora, Arsene & Benedict 17102 (US); Sandoval, Ripley & Barneby 8347 (NY); San Miguel, Standley 5116 (NY, US); Santa Fe, Brendan 23030 (SMU).

North Dakota: Barnes, Fattig 2858 (DUKE); Benson, Welsh 778 (ISC); Billings, Bollen 7 July 1891 (NY); Burleigh, Seymour 29 August 1894 (DUKE); Cass, Waldron & Manns 16 August 1801 (US); Grant, Bell 1907 (BM); Kidder, Mearns 22 July 1889 (US); Lamoure, H. L. B. Summer 1927 (DUKE); McHenry, Brown 53-50 (ISC); Morton, Rollins and Munoz 2815 (US); Nelson, Seymour et al 16019 (KY, SMU); Ramsey, Pope 20 August 1907 (US); Richland, Stevens 25 July 1949 (US); Stark, Holgate 23 July 1908 (US); Williams, Welsh 772 (ISC).

Oklahoma: Blaine, Stevens 817 (NY, OKLA); Bryan, Cory 58855 (OKLA, SMU); Caddo, Demaree 13072 (NY, SMU, US); Carter, Tharp 7111 (TEX, US); Cherokee, Wallis 2329 (OKLA); Choctaw, Wemple 420 (ISC); Cleveland, Demaree 13184 (GA, ISC, OKLA, SMU, TEX, US); Comanche, Demaree 13000 (GA, SMU, US); Creek, Bush 72 (NY, US); Custer, Waterfall 2234 (OKLA); Delaware, Wallis 1757 (OKLA); Garvin, Duffer 513 (OKLA); Haskell, Bebb 5469 (OKLA); Johnston, Tharp 19 June 1929 (TEX); Kingfisher, Byers 48 (OKLA); Lincoln, Eaton 31 (OKLA); Logan, Davy 247 (TEX); Love, Cory 59016 (OKLA, SMU); Marshall, Cory 58957 (SMU); Mayes, Wallis 2984 (OKLA); McClain, Demaree 13095 (GA, NY, OKLA, SMU, TEX, US); McCurtain, Waterfall 12429 (OKLA, SMU, US); Murray, Barkley & Barkley 21 OK 002 (SMU, TEX); Muskogee, Waterfall 9558 (OKLA, SMU); Noble, Divine 32 (TEX); Oklahoma, Waterfall 2836 (NY); Osage, Webster 4254 (SMU); Ottawa, Wallis 4636 (OKLA); Payne, Merrifield 43 (ISC); Pittsburg, Rogers 20 June 1957 (OKLA); Pontotoc, McCoy 733 (OKLA); Pottawatomie, Pope 65 (OKLA);

Roger Mills, Waterfall 7732 (OKLA, TEX); Sequoyah, Wallis 4632 (OKLA, SMU).

South Dakota: Brookings, Pammel 3 August 1918 (ISC); Brule, Isely 6038 (ISC, US); Charles Mix, Aikman 19 July 1955 (ISC, US); Custer, Rydberg 610 (NY); Day, collector unknown year 1894 (OKLA); Deuel, Isely 8124 (ISC); Fall River, Rydberg 611 (NY, US); Grant, Pammel 31 July 1918 (ISC); Haakon, Gilly et al 823 (RM); Hamlin, Isely 8120 (ISC); Hanson, Weber 17 August 1927 (FLAS); Harding, Visher 232 (RM); Kingsbury, Isely 8116 (ISC); Meade, Forwood 70, 70a (US); Mellette, Tolstead 4-443 (ISC); Minnehaha, Thornber August 1892 (US); Perkins, Visher 642 (RM); Todd, Tolstead 4-367 (ISC); Turner, Johnson 49 (ISC, NY).

Texas: Bell, Wolff 833 (US); Culberson, Warnock 6321 (TEX); Erath, Gough year 1924 (US); Grayson, Johnson 17 (TEX); Lamar, Turner & Tharp 3123 (TEX); Montague, Whitehouse 10080 (SMU); Palo Pinto, Tracy 8042 (US); Red River, Tharp 47398 (TEX); Wheeler, Tharp 17 June 1929 (TEX, US); Wichita, Tharp 586 (NY, TEX).

Wisconsin: Burnett, Fassett 16749 (DUKE); Dane, Grether 8185 (KY); Juneau, Mearns 230 (US); La Crosse, Fassett 4405 (DUKE); Pierce, Fassett 4407 (DUKE); Rock, Wadmond 2793 (ISC); Sauk, Steele 77 (US); Trempealeau, Hermann 20 June 1937 (NY); Walworth, Fassett 17030 (DUKE); Winnebago, Clemens 30 July 1909 (ISC).

Wyoming: Albany, Nelson 7418 (ISC, NY, US); Campbell, Porter & Porter 7577 (RM); Converse, Long & Ownbey 1060 (RM); Crook, Porter & Porter 8389 (RM); Laramie, Nelson 3641 (NY, US); Natrona, Jozwik 243 (RM); Sheridan, Rollins 560 (NY).

Petalostemon sabinale -- specimens examined

Texas: County unknown. Reverchon 1516 (MO). Brewster, Warnock 11398 (TEX). Uvalde, Palmer 13337 (US, MO). Val Verde, Cory 44424 (TEX).

Petalostemon searlsiae -- specimens examined

Arizona: County unknown. Jones 5095g, Pagumpa (US); Jones 11 June 1890, Willow Spring (US). Coconino, Collom 1074 (US); Maguire 12238 (NY); Maguire 12275 (NY); McDougal 15 June 1891 (US); Peebles 13055 (US); Ward 9 June 1901 (NY, US). Mohave, Lemmon and wife June 1884 (US). Yavapai, Toumey 560 (NY).

California: Inyo, Roos & Roos 6167 (NY). San Bernardino, Alexander & Kellogg 1401 (NY, US); Brandegge 26 May 1902 (US); Wolf 9659 (NY); Wolf 9666 (NY, OKLA, TEX).

Nevada: County unknown. Gooding 961, Kershaw, Meadoro Valley Wash (RM). Churchill, Maguire & Holmgren 25409 (NY, US). Clark, Alexander & Kellogg 1643 (US); Bleak 18 May 1928 (ISC); Clokey 7155 (ISC, NY); Clokey 7158 (NY, RM); Clokey 8004

(DUKE, GA, ISC, NO, NY, OKLA, RM, TENN, TEX, US); Clokey & Anderson 7157 (NY, TEX); Clokey & Bean 7156 (ISC, NY, OKLA); Maguire 18012 (NY); Purpus 6059 (US); Tidestrom 9654 (US); Train 1991 (NY). Elko. Holmgren 19 (NY); Stramler 5 June 1939 (NY); Train 3816 (NY, TEX). Lincoln. Gentry 35 (US); Gooding May 1902 (RM); Mason 12446 (RM); Ripley & Barneby 4400 (NY). Nye. Maguire & Holmgren 25308 (NY).

Utah: County unknown. Bishop 196 (US); Thompson year 1872 (US). Box Elder. Pearse 242 (NY). Garfield. Harrison 9131 (ISC); McArthur & Beck 162 (ISC). Iron. Ogden 11 June 1961 (ISC). Juab. Jones 4 June 1891 (NY, RM, US). Kane. Maguire 12286 (NY); Maguire 12306 (NY); Maguire 18881 (NY); Ripley & Barneby 4843 (NY); Tidestrom 2408 (US). Washington. Jones 7 May 1923 (US); Jones 51391 (US); Jones 51831 (US); Jones 5196k (US); Jones 5224j (US); Jones 5229 (US); Palmer 131 (NY, US); Pennell & Schaeffer 21665 (NY); Woodbury year 1927 (US).

Petalostemon tenue -- specimens examined

Texas: Bandera. Palmer 12257 (NY); Shinners 16912 (SMU); Tharp 6402 (TEX, US); Turner 3835 (TEX); Turner 3839 (TEX). Bexar. Clemens & Clemens 654 (RM); Groth 148 (NY); Shulz 97 (US); Shulz 252 (US). Blanco. Cory 42574 (TEX). Bosque. Shinners 14990 (OKLA, ISC, TEX); Whitehouse 21 July 1929 (TEX). Burnet. McJohnson & McCart 5356 (TEX); Wemple 235 (ISC). Callahan. Isely 8340 (ISC); Wemple 250 (ISC). Coke. Palmer 12437 (NY). Coleman. Warnock 46346 (TEX). Coryell. Rose-Innes & Moon 1324 (TEX); Turner 3812-A (SMU, TEX). Erath. Cory 58072 (OKLA, SMU); Shinners 15007 (ISC, SMU). Hamilton. Gould 6842 (SMU, TEX). Hays. Thurber, Hays (NY). Hood. Blackwell 86 (SMU); Wemple 243 (ISC); Zischkale 19 June 1949 (SMU). Irion. collector unknown 10 July 1928 (TEX); Tharp 6403 (US); Warnock T335 (TEX, US). Johnson. Bottimer 27 July 1959 (TEX); Shinners 27792 (SMU). Lampasas. Warnock 46318 (TEX); Wemple 236, 238 (ISC); Whitehouse 14 July 1931 (TEX). Menard. Bottimer 922 (FSU). Nolan. Palmer 34588a (NY, US). Palo Pinto. Tracy 8042 (NY, TEX). Parker. Wemple 244 (ISC); York 29 (TEX). Schleisher. Heed 263 (FSU). Sutton. Heed 265 (FSU). Tarrant. McCart 2088 (TEX); Reed 487 (FSU). Taylor. Henderson 62-721 (FSU); Tolstead 7369 (SMU, TEX). Tom Green. Bray 375 (US); Tweedy May 1880 (US). Travis. Whitehouse 9 July 1929 (TEX). Wise. Shinners 24089 (ISC, SMU, TEX).

Petalostemon tenuifolium -- specimens examined

Colorado: Baca. Inglis 55 (SMU). Las Animas. Rogers (US); Rogers 6022 (ISC).
 Kansas: Clark. Welsh 672 (ISC). Gove. Hulbert 3541

(OKLA). Morton. Hitchcock 94 (NY); Rydberg & Imler 957, 957A (NY). Stevens. Wemple 325 (ISC).

New Mexico: County unknown. Pease, Cabra Springs (US). Colfax. Lucas 142 (TEX). DeBaca. Shinnars 20912 (SMU). Guadalupe. Arsene & Benedict 16872 (US); Arsene & Benedict 16987 (US); Degener 4513 (NY); Isely & Isely 8832. Harding. Eggleston 20176 (NY, US). Mora. Arsene & Benedict 17121 (US). Quay. Goodman 3063 (ISC, NY). Sandoval. Rothrock 81 (US). San Miguel. Arsene 21 June 1927 (US). Santa Fe. Castetta 1262, 1057 (RM). Union. Gooding A5654 (NY); Iltis & Iltis 4261 (SMU).

Oklahoma: Cimarron. Goodman & Kelting 5381 (NY, TEX); Rigney 125 (OKLA); Rogers 4702 (US); Waterfall 10793 (OKLA); Welsh 696 (ISC); Wemple 329, 330, 335 (ISC). Payne. Rigney 84 (OKLA). Texas. Waterfall 7412 (OKLA); Waterfall 7964 (OKLA).

Texas: Dallam. McLaughlin 15 June 1938 (OKLA); McVaugh 7263 (SMU, TEX); York & Rogers 183 (SMU). Deafsmith. Osterhout 37 (US). Donley. Ripley & Barneby 7503 (NY). Garza. Palmer 13855 (US); Ruth 1310 (US); Tharp 9 July 1941 (ISC, NY, TEX). Gray. Wemple 367, 373 (ISC). Hall. Thames June & July 1926 (TEX). Hemphill. Wemple 378 (ISC). Hutchinson. Cory 50340 (SMU). Lipscomb. Wallis 5060 (OKLA, SMU). Lubbock. Bray 29 May 1899 (TEX); Demaree 7690 (SMU, US); Wooten 3 May 1925 (US). Moore. Wemple 346, 353 (ISC). Ochiltree. Tharp 4410 (TEX); Wallis 4806 (OKLA, SMU); Wallis 7215 (SMU). Oldham. Bailey 132 (US); Reverchon 3006 (NY, US). Potter. Reverchon 3008 (NY, US); Wemple 354 (ISC). Randall. Correll & Correll 13048 (SMU); Cory 50436 (NY, SMU, TEX); Palmer 12503 (NY, US); Reverchon 3748 (NY); Tharp 7112 (TEX, US); Wemple 361 (ISC); Young 9 September 1917 (TEX). Roberts. Wallis 4940 (OKLA, SMU); Wemple 375376 (ISC). Sherman. Isely 6396 (ISC); Jespersen & Jespersen 2699 (NO, NY, RM, SMU, US). Swisher. Wemple 253 (ISC); Whitehouse 9955 (SMU).

Petalostemon villosus -- specimens examined

CANADA

Saskatchewan: Ledingham et al 2280, W of Caron (SMU, TEX); Ledingham et al 2284, W of Caron (ISC).

UNITED STATES

Arizona: County unknown. Loew 194 (US).
 Colorado: County unknown. Johnson 191 (RM); Las Animas. Rogers 4964 (US). Logan. Osterhout 12 August 1896 (RM, US). Sedgwick. Osterhout 8201 (RM). Washington. Shantz & Piemeisel 1468 (US). Weld. Ewan 12272 & 12272 (NO); Ramaley 15174 (TEX). Yuma. Boyes August 1915 (RM); Eggleston 15170 & 15530 (NY); Osterhout 4062 (NY, RM); Shantz 14 August 1907, 712, 1272, 1314 (US).
 Iowa: Blackhawk. Grant 11197 (ISC).
 Kansas: County unknown. Carleton 23 October 1892,

Arkalon. Dickinson. Werthner July - August 1878 (US). Finney. Letterman 20 (ISC); Richards 3051 (SMU); Smyth 166 (US).
Hamilton. Rose and Fitch 17168 (NY, US); Thompson 96 (NY, US);
Welsh 699 (ISC). Harper. Hitchcock 658 (NY, RM, US); Rydberg & Imler 623 (NY). Kearney. Rydberg & Imler 927 (NY); Wemple 315 (ISC). Miami. Oyster July 1887 (NY). Morris. MacKenzie 8 July 1895 (NY). Morton. Richards 2974 (SMU). Phillips. Smyth 334 (NY). Pratt. Horr & Franklin E 328 (DUKE, FLAS, ISC, NO, OKLA, RM, SMU, TEX, US). Rooks. Runyon 238 (RM).
Reno. Carleton 291 (ISC); McGregor 15851 (NY, SMU); Smyth 50 (US). Stevens. Swink 35 (NY); Wemple 320 (ISC). Wyandotte. MacKenzie 928 (NY).

Michigan: Washtenaw. Clark, no date or number (NY).

Minnesota: Anoka. Moore & Moore 10266 (DUKE, ISC, SMU, TENN, TEX, US). Chisago. Pammel 4 August 1919 (ISC); Taylor August 1892 (RM, US). Crow Wing. Sandberg 866 (OKLA, RM).
Goodhue. Pammel 2 August 1923 (ISC). Hennepin. Aiton August 1891 (NY, RM, TENN); Aiton September 1891 (DUKE, RM); Burglehaus August 1891 (ISC); Oertlund August 1878 (NY); Sandberg July 1891 (NY); Sandberg August 1891 (RM); Sandberg 4920 (NY); Sheldon September 1891 (NY, TENN, US); Sheldon September 1892 (US); Sheldon September 1894 (NY). Morrison. Hotchkiss & Jones 4118 (US). Polk. Bormann 99 (DUKE); Johnson 521 (ISC, NY). Winona. White July 1891 (RM).

Missouri: Franklin. Letterman July 1896 (US).

Montana: County unknown. Ward year 1883 (US). Dawson. Ward 6 August 1883 (US).

Nebraska: County unknown. Clements 2735 (ISC, NY, US); Williams 10 June 1888, Ash Grove (US). Antelope. Harper 22 August 1887 (US); Rohrbach 25 (TEX). Box Butte. Paige no number or date (ISC); Webber 302 (US). Brown. Rutter no number, or date (US). Chase. Tolstead 411013 (ISC). Cherry. Isely 6521 (ISC). Deuel. Rydberg 62 (NY). Dowes. Mitchell 851 (ISC). Franklin. Harshbarger 1670 (US). Grant. Crider & Atkins 102 (RM); Rydberg 1589 (NY). Holt. no collector 15 August 1906; Chambers (TEX); Fults 24 September 1934 (ISC); Hodges 2 - 105 (ISC); Winter 29 (US). Hooker. Rydberg 1589 (US). Kearney. Hapeman 25 July 1891 (NY, RM); Hapeman 6 August 1929 (NO); Hapeman 21 July 1930 (TEX); Hapeman 1 August 1932 (TENN); Hapeman 20 July 1930 (ISC); Hapeman 25 July 1935 (DUKE; Rydberg 5 (NY). Loup. Mohler 44 (ISC). Sheridan. Buchanan 2 - 20 August 1905 (ISC). Sioux. Drushel 7027 (US). Thomas. Bethel 12 August 1924 (US); Blumer 8 September 1902 (ISC); Webber 7 August 1889 (US).

North Dakota: Benson. Lunell 28 July 1911 (NY, RM); Lunell 14 August 1911 (NY); Stevens 11 August 1913 (FLAS); Stevens 13 August 1913 (RM). Grant. Stevens 27 August 1952 (US). McHenry. Stevens & Kluender 18 August 1935 (RM).
Morton. Stevens 14 August 1954 (US). Ransom. Perrine 7 August 1900 (NY). Richland. Stevens 25 July 1949.

Oklahoma: County unknown. Palmer 86 (US). Beaver. Goodman & Kelting 5337 (NY, TEX). Blaine. Wallis 3404 (OKLA); Waterfall 8119 (OKLA). Custer. Waterfall 7351 (OKLA). Harper. Smith 21 (TEX); Welsh 676 (ISC). Kay. Davy 86 (OKLA); Hastings 99 (OKLA); Johnson 153 (OKLA); White 3 August 1899 (NY). Major. Stevens 1719 (OKLA, SMU, US). Muskogee. Kilgore 321 (OKLA). Oklahoma. Waterfall 2095 (NY, OKLA); Waterfall 2182 (OKLA). Payne. Waugh 324 (US). Roger Mills. Engleman 3016 (SMU). Woods. Stevens 1672 (OKLA); Stevens 1716 (NY, OKLA, SMU, US); White 4 July 1900 (RM). Woodward. Gruver 1228 (TEX); Hymowitz 202 (OKLA); Jackson 2085 (OKLA); Waterfall 3109 (OKLA).

South Dakota: County unknown. Skinner 185 (RM); Wallace 7 September 1896, Corn Creek (NY). Bennett. Over 16090 (US); Visher 2314 (NY). Fall River. Porter & Porter 8801 (RM). Harding. Visher 238 (RM). Fennington. Over 1908 (US); Williams 29 August 1891 (NY). Todd. Tolstead 4 - 504 (ISC). Tripp. Wallace 30 June 1896 (NY).

Texas: Bailey. Cory 37481 (FSU); Ferris & Duncan 3476 (NY); McVaugh 7288 (NY, SMU); Reed 1 (FSU); Tharp 14 June 1929 (TEX). Callahan. Henderson 62 - 756 (FSU); Isely 8351 (ISC); Wemple 251 (ISC). Collingsworth. Taylor 1 August 1 1941 (TEX). Hall. Reverchon 3749 (NY, US). Hemphill. Howell 96 (US); Howell 99 (US); Rowell 4215 (OKLA). Hockley. Reed 3327 (US). Jones. Henderson 62 - 810 (ISC, SMU). Lamb. Harris 38 (US). Lipscomb. Howell 74 (US); Wallis 5130 (SMU). Mitchell. Pohl 4568 (ISC, SMU). Roberts. Wallis 5035 (OKLA). Wheeler. Isely & Isely 8878 (ISC); Tharp 4396 (TEX, US).

Wisconsin: Buffalo. Holzinger July 1890 (US). La Crosse. Hartley & Peterson 2029 (US); Pammel year 1887 (ISC). Pepin. Fassett 4415 (DUKE); Hale year 1861 (NY); Luders August 1887 (US). Pierce. Jones 35 (SMU). St. Croix. Fassett 17032 (DUKE).