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A Distributional and Taxonomic Study of Ratibida Columnifera Var. Columnifera, Ratiba Columnifera Var. Pucherrima, and Their Hybrids in New Mexico

Walter W. Marshall

RATIBIDA COLUMNIFERA - MARSHALL

A DISTRIBUTIONAL AND TAXONOMIC STUDY OF RATIBIDA COLUMNIFERA VAR. COLUMNIFERA, RATIBIDA COLUMNIFERA VAR. PULCHERRIMA, AND THEIR HYBRIDS IN NEW MEXICO

by

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CHAPTER I

INTRODUCTION

The classification and distribution of Ratibida columnifera var. columnifera Woot. & Standl. and R. columnifera var. pulcherrima (DC.) Woot. & Standl. are complex. Some floras list R. columnifera var. pulcherrima as a purple colored form or variety of the species while other authors refer to this taxon as separate species of Ratibida. The purpose of this study is to clarify the taxonomic status of the two forms by determining the similarities and differences in morphology, distribution, taxonomy, and ecology.

An attempt has been made to determine the route by which R. columnifera columnifera and R. columnifera pulcherrima were distributed. After this was determined, a theory was formulated which correlated the pattern of distribution with the location of pure populations of the forms.

This problem was limited in its scope to New Mexico. For the sake of clarity, a general survey was made of the distribution of R. columnifera columnifera and R. columnifera pulcherrima in the United States. The purpose of the survey was to determine the possible routes of entry of the forms into New Mexico.

Since color was found to be a major distinguishing characteristic between these forms and their hybrids, an additional analysis was made of the pigments. A correlation was found between R. columnifera columnifera, R. columnifera pulcherrima, and their hybrids on the basis of a color index and a color pattern. An analysis of the color-pattern classes has been made in order to obtain some idea as to the type of inheritance involved.

Since color was found to be a [illegible] distinguishing characteristic between the gray forms and the [illegible], an additional analysis was made of the pigments. A [illegible] relation was found between _P. columbiana [illegible]_, _P. columbiana pulcherrima_, and [illegible] hybrids on the basis of a color index and a color pattern. An analysis of the color-pattern classes has been made in order to obtain some idea of the [illegible].

CHAPTER II

MATERIALS AND METHODS

The dried material used in this study is deposited in the herbarium of the University of New Mexico. A total of 248 specimens were examined. The color photographs of living plants were taken in the field to indicate the general habitats and the color patterns of the species and hybrids.

The following measurements were made of the dried specimens: (1) cone length and width; (2) ray-flower length and width; (3) cone-flower length; (4) achene length. In addition, the following characteristics were noted: (1) number and type of stem ribs; (2) nature, type, and location of leaves; (3) type and location of pubescence.

A quantitative study was made of the ray-flower pigments. Sections weighing 5.0 mgm. were refluxed for 45 minutes in a 10 ml. mixture of equal parts of 95% ethanol and propionic acid, and the sample was removed and permitted to stand at room temperature for three hours. At this time the maximum color was obtained and a reading was made on a Klett-Summerson Colorimeter.

Ideographs (figs, 3-25) were drawn in order to study patterns of color. The size of the ligule was disregarded for the purpose of this analysis because the patterns remained the same general shape regardless of the size of the ligule. Rectangles simulated the general shape of the ligule, and the patterns were in the same proportion found in the ray-flower. It should also be noted that the patterns represented in figs. 4-26 were collected in an area dominated by _R._ _columnifera_ _columnifera_ which resulted in a dominance of yellow pigment in the pattern. The same patterns but with a dominant purple coloration were present in areas where _R_. _columnifera_ _pulcherrima_ was the most abundant form.

The fertility of the pollen was determined by staining the pollen grains, dissected from the anthers, with methylene blue in lactophenol for 24 hours according to the method of R. C. Jackson and A. T. Guard. Those pollen grains that exhibited a uniform dark stain were considered fertile. Pollen grains that were of a light uneven stain or did not stain at all were considered non-viable.

One mass collection was taken of a hybrid population. This collection was limited to an area of approximately 625 square yards of open meadow four miles

west of Elk, New Mexico. All plants of *R. columnifera columnifera*, *R. columnifera pulcherrima*, and their hybrids were counted. A sample was collected which was proportional to the parental and hybrid types.

CHAPTER III

TAXONOMY AND ECOLOGY

A. Description of the Species

RATIBIDA COLUMNIFERA (Nutt.) Woot. & Standl. in Contr. U. S. Nat. Herb. (Fl. N. Mex.) 19:706, 1915.

RATIBIDA COLUMNARIS (Sims) D. Don in Sweet's Brit. Fl. Gard. vii: (Ser. Ziv), t. 361. 1836.

LEPACHYS COLUMNARIS (Sims) Steud. Nom. ed. II, ii, 439. 1895.

Perennial, arising from a horizontal rootstalk; stem simple or branched, hexagonal in cross section with alternate ridges and depressions, strigose hirsute; leaves alternate, pinnately dissected, the basal ones larger; heads solitary and cylindrical; receptacle columnar; disc flowers 3 mm. long with a very short tube, 5-lobed, glabrous; ray-flowers yellow, the tips notched; achenes 2 mm. long, flat, glabrous; pappus coroniform.

RATIBIDA COLUMNIFERA var. PULCHERRIMA (DC.) Woot. & Standl. in Contr. U. S. Nat. Herb. (Fl. N. Mex.) 19:706, 1915.

RATIBIDA COLUMNARIS var PULCHERRIMA (DC.) D. Don in Sweet's Brit. Fl. Gard. vii (Ser. Ziv), t. 361. 1836.

LEPACHYS COLUMNARIS var. PULCHERRIMA (DC.) Steud. Nom. ed. II, ii, 439. 1895.

Color was found to be the only difference that exists between R. columnifera columnifera and R.

columnifera pulcherrima. *Ratibida columnifera columnifera* has pure yellow ligules, while those of *R. columnifera pulcherrima* are mostly purple (fig. 1). The hybrids between the two have distribution patterns consisting of the two colors found in the parents (fig. 2). The ideographs in figs. 3-25 summarize the typical patterns of pigment found in the hybrids from various populations.

In the citation of specimens, all collected in New Mexico, the following symbols are used for convenience and clarity:

1. P--designates a pure purple population (*Ratibida columnifera pulcherrima*).
2. Y--designates a pure yellow population (*Ratibida columnifera columnifera*).
3. X--designates a purple-yellow mixture, considered here as a putative hybrid between the two varieties previously mentioned.

B. Specimens Examined

Eddy Co.: roadside drain, 4 mi. east of Hope on U. S. 83, elevation 4100 ft., June 6, 1957, Marshall R2X; roadside drain, 5 mi. east of Hope on U. S. 83, elevation 4000 ft., June 6, 1957, Marshall R1X; railroad right-of-way, east of Artesia city limits, elevation 3400 ft., June 6, 1957, Marshall R4X; roadside drain, west of Hope city limits, elevation 4100 ft., June 6, 1957, Marshall R8P; roadside drain, 5 mi. north of Artesia on U. S. 285, elevation 3400 ft.,

June 7, 1957, Marshall R5X; swampy drain area, west of Artesia city limits, elevation 3300 ft., June 7, 1957, Marshall R3X; roadside drain, Rattlesnake Springs, Carlsbad Caverns, May 22, 1952, Castetter and Dittmer 7272; roadside drain, 5 miles west of Carlsbad, May 18, 1951, Castetter and Dittmer 5268. Lea Co.: roadside drain, west of Caprock on U. S. 380, elevation 3900 ft., June 7, 1957, Marshall R6X; roadside drain, 5 mi. south of Hobbs, June 5, 1952, Castetter 7725. Torrance Co.: roadside drain, Inlow Youth Camp Road in Cibola National Forest, Fourth of July Canyon, elevation 6800 ft., June 28, 1957, Marshall R10P; railroad siding, 14 mi. south of Moriarity on N. M. 41, elevation 6100 ft., July 6, 1957, Marshall R22P; roadside drain, 7 mi. south of Tajique on N. M. 55, elevation 6600 ft., July 6, 1957, Marshall R23P. Bernalillo Co.: roadside drain, 1 mi. south of Cedar Crest, elevation 7500 ft., July 6, 1957, Marshall R20X; roadside drain just above Cedar Crest, elevation 7500 ft., July 6, 1957, Marshall R21P; gravelly soil, Sandia Mountains Fur Farm, July 30, 1937, Abbott 4247; east side of Sandia Mountains, 1 mi. south of Antonito, June 30, 1956, R. C. Jackson 2302-3. Otero Co.: roadside drain, just east of Mescalero on N. M. 24, elevation 7000 ft., July 20, 1957, Marshall R30Y; roadside drain, 1 mi. east of Mescalero on N. M. 83, elevation 7000 ft., July 20, 1957, Marshall R31X;

roadside drain, west of Mayhill on N. M. 83, elevation 7400 ft., July 20, 1957, Marshall R32X; roadside drain, James Canyon Road southeast of Cloudcroft, elevation 7300 ft., July 20, 1957, Marshall R33X; roadside drain, Silver Springs Canyon Road northeast of Cloudcroft, elevation 7800 ft., July 21, 1957, Marshall R34X; open meadow 15 mi. northeast of Cloudcroft on N. M. 24, elevation 7200 ft., July 21, 1957, Marshall R35X; open meadow 4 mi. south of Mescalero on N. M. 24, elevation 7300 ft., July 21, 1957, Marshall R36P; open meadow, 12 mi. south of U. S. 70 on Elk Canyon Road, elevation 7300 ft., July 21, 1957, Marshall R38X; roadside drain, Sixteen Spring Canyon Road, 4 mi. west of Elk Canyon Road, elevation 6800 ft., July 21, 1957, Marshall R40X; banks of Ruidoso Creek, Wingfield Ranch in White Mountains, elevation 6400 ft., July 8, 1895, E. O. Wooton 17982; Cox Canyon, Cloudcroft and Ruidoso, July 3, 1949, Castetter and Dittmer 4478. Valencia Co.: open meadow, 2 mi. west of the ice caves on N. M. 53, elevation 7800 ft., July 27, 1957, Marshall R40X. Rio Arriba Co.: open meadow, 1 mi. north of Cuba on N. M. 126, elevation 7000 ft., July 28, 1957, Marshall R42X; roadside drain, 4 mi. west of Chama on U. S. 84, elevation 7300 ft., Aug. 10, 1957, Marshall R60X; pinyon-juniper, 40 miles south of Tierra Amarilla, July 22, 1949, Castetter and Dittmer 4477. Santa Fe Co.:

roadside drain, west of [illegible], elevation
7400 ft., July 20, 1957, [illegible];
Jemez Canyon Road [illegible],
7300 ft., July 20, 1957, Marshall [illegible];
Silver Springs Canyon Road [illegible],
elevation 7800 ft., July 21, 1957, Marshall [illegible];
meadow 15 mi. northeast of Cloudcroft [illegible],
elevation 7200 ft., July 21, 1957, Marshall [illegible];
meadow 4 mi. south of [illegible] on N. M. 24, elevation
7300 ft., July 21, 1957, Marshall [illegible];
mi. south of U. S. 70 on [illegible], elevation 75[illegible]
ft., July 21, 1957, Marshall [illegible], roadside drain,
Sixteen Spring Canyon Road, [illegible] mi. north of [illegible] Canyon
Road, elevation 6800 ft., July 21, 1957, Marshall [illegible];
banks of Ruidoso Creek, [illegible]
Mountains, elevation 6400 ft., July [illegible], E. O.
Wooton 17932; Cox Canyon, Cloudcroft [illegible], July
3, 1949, Castetter and Dittmer 4473. [illegible] Co.:
open meadow, 2 mi. east of [illegible],
elevation 7500 ft., July 29, 1957, Marshall [illegible].
Arriba Co.: open meadow, 1 mi. north of [illegible] on N. M.
126, elevation 9200 ft., July [illegible], 1957, Marshall [illegible];
roadside drain, 4 mi. west of [illegible] on N. M. [illegible], eleva-
tion 7300 ft., Aug. 16, 1957, Marshall [illegible];
juniper, 50 miles [illegible], July [illegible],
1949, Castetter and [illegible]

roadside drain, 16 miles southeast of Santa Fe on U. S. 84, elevation 6900 ft., Aug. 3, 1957, Marshall R50X. San Miguel Co.: roadside drain, 1 mi. north of Rowe on U. S. 84, elevation 6800 ft., Aug. 3, 1957, Marshall R51X. Union Co.: roadside drain, Don Carlos Ranch 7 mi. east of Gladstone on U. S. 58, elevation 5800 ft., Aug. 3, 1957, Marshall R52X; Bear Canyon, Mescalero Reservation, Aug. 1, 1938, Humphrey 12294; roadside drain, Cimarron Canyon, elevation 8200 ft., July 6, 1935, Castetter 2546; prairies southwest of Kenton, Okla., (just in N. M.), Aug. 9, 1951, Clark 15271; meadow along Cimarron River, east of Folsom, July 24, 1952, Dittmer 9661. Colfax Co.: roadside drain, 8 mi. northeast of Cimarron on U. S. 64, elevation 6600 ft., Aug. 3, 1957, Marshall R53X; pinyon-juniper, rocky ground, Ojo Feliz, Aug. 10, 1949, Gordon and Norris 4549; open areas along Cimarron River, 8 mi. east of Eagle Nest Lake, Aug. 8, 1951, Clark 5865. Taos Co.: open meadow, 1 mi. north of Taos on County Road 3, elevation 6500 ft., Aug. 4, 1957, Marshall R54X. Catron Co.: open woods, east of Aragon, Aug. 17, 1942, Clark 23480; meadow near Apache Creek on Route 12, July 17, 1952, Dittmer 8662. Mora Co.: Solomon Ranch, La Cueva, Sept. 22, 1954, E. Williams 16855. Lincoln Co.: pine-spruce, banks of Bonita Lake, elevation 7500 ft., Aug. 18, 1949, Gordon and Dunn 9550.

roadside drain, [illegible] miles southeast of [illegible] on U. S. 84, elevation [illegible] ft., Aug. [illegible], 1957, Maxwell [illegible]. San Miguel Co.: [illegible], 1 mi. [illegible] on U. S. 84, elevation [illegible] ft., Aug. 3, 1957, Maxwell K512. Union Co.: roadside drain, [illegible] east of Gladstone on U. S. [illegible], elevation [illegible] ft., Aug. 3, 1957, Maxwell [illegible]; [illegible] Reservation, [illegible] 1933 [illegible]; drain, Cimarron Canyon, [illegible] 1955, Castetter [illegible] [illegible] Okla., (just in N. M.), [illegible], 1951, [illegible]; meadow along Cimarron River, [illegible] 24, 1952, Dittmer 3061. Colfax Co.: roadside drain, [illegible] northeast of Cimarron on U. S. 64, elevation [illegible] ft., Aug. 3, 1957, Maxwell K511 [illegible] ground, Ojo Feliz, Aug. 10, 1954, [illegible] 4949; open areas along Cimarron River, [illegible] Eagle Nest Lake, Aug. 6, 1951, [illegible]. Taos Co.: open meadow, 1 mi. north of Taos [illegible], elevation 6900 ft., Aug. [illegible], 1957, [illegible]. Otero Co.: open woods, [illegible], [illegible] 29400; meadow [illegible] Creek [illegible], [illegible] 1952, [illegible]. [illegible] Co.: [illegible], Sept. 22, 1954, [illegible]. [illegible]: spruce, [illegible] Lake, elevation [illegible] ft., Aug. [illegible], 1949, [illegible].

C. Ecology

Both forms can tolerate a dry, semi-arid environment, but neither can thrive there. Plants growing in such habitats are smaller and less numerous than those found in moist areas. The larger populations were found in open meadows, roadside drainage areas, and railroad right-of-ways. These are areas where water would collect and not run off rapidly. A typical habitat is shown in fig. 26.

Both forms grow at an elevation of 3000 feet in the desert plains to 7800 feet in the Jemez Mountains. The optimum elevation appears to be in the range of 6800-7500 feet. The plants are observed to be larger and hardier within this range of elevation.

<u>Ratibida</u> <u>columnifera</u> <u>columnifera</u> and <u>R</u>. <u>columnifera</u> <u>pulcherrima</u> are found in silt-loam soils suitable for grasslands. However, the range of tolerance is great because these forms can also be found in sandy and gravelly types of soil, but under these conditions the size of the plant is small.

Figure 1

<u>Ratibida columnifera columnifera</u>

Figure 2

Hybrid between *Ratibida columnifera columnifera* and *Ratibida columnifera pulcherrima*

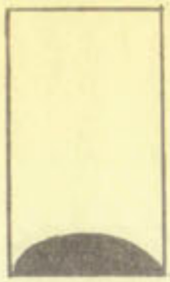
Figures 3 - 25

Ideographs showing the color patterns

of the hybrids


R31X2


R31X4


R31X5


R31X6


R31X7


R32X2


R32X3


R32X4


R32X5


R32X6


R32X7


R33X1a


R33X1b


R33X2


R33X3


R33X4


R33X5


R33X6


R34X1


R20X1


R20X5


R20X2

KEY TO COLOR:

BLACK INDICATES YELLOW PIGMENT

WHITE INDICATES PURPLE PIGMENT

Figure 26

Habitat of _R_. _columnifera_ _columnifera_, _R_. _columnifera_ _pulcherrima_, and their hybrids

CHAPTER IV

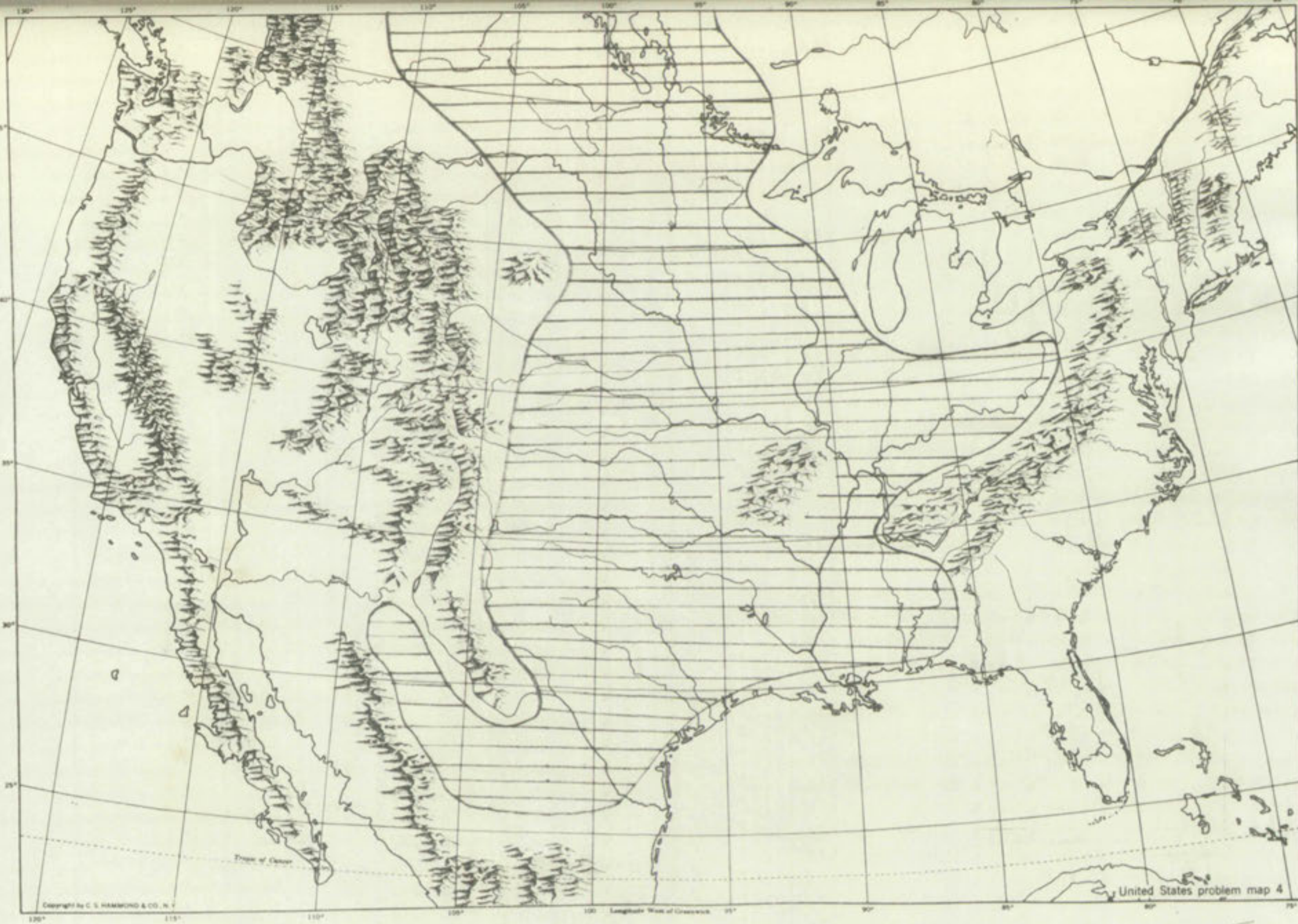
GEOGRAPHICAL DISTRIBUTION

In order to determine where these forms entered New Mexico, it is necessary to know something of their range (see the map in fig. 27). Sharp (1935, p. 67) defines Nebraska as the center of the range of Ratibida. From there, Ratibida was introduced into the Dakotas and Montana. The genus followed roadsides and railroad right-of-ways into the dry prairies of Texas, New Mexico, and northern Mexico.

No mention of the presence of Ratibida has been noted in any floras for the Atlantic States or for areas west of Arizona. The distribution of R. columnifera columnifera and R. columnifera pulcherrima in the United States is indicated on the map of fig. 27. The map indicating the range of the genus was compiled from the floras of Alabama, Arizona, Colorado, Indiana, Kansas, Minnesota, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, and the State of Chihuahua, Mexico, where Ratibida is located. Fig. 28 indicates the results of a detailed herbarium and field of survey of New Mexico. This survey is supplemented from sources used in the general distributional study.

Figure 27

Range of _Ratibida_ in the United States


United States problem map 4
Copyright by C. S. HAMMOND & CO., N.Y.
Longitude West of Greenwich
Tropic of Cancer

173

Figure 28

Distribution of _Ratibida_ _columnifera_ _columnifera_ and _Ratibida_ _columnifera_ _pulcherrima_ in New Mexico

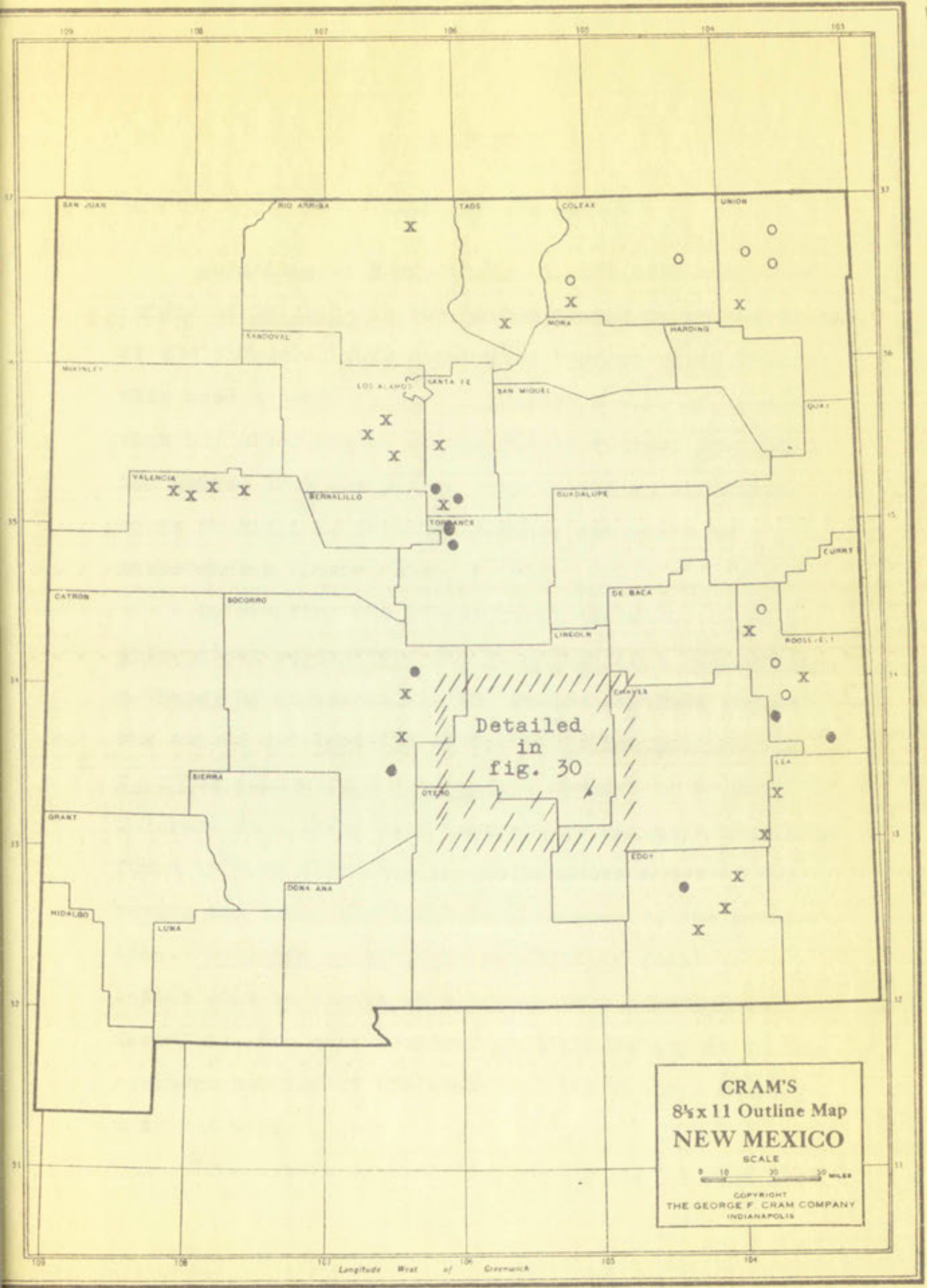
Key

o _R_. _columnifera_ _columnifera_

● _R_. _columnifera_ _pulcherrima_

x Hybrids

18a


SAN JUAN
RIO ARRIBA
TAOS
COLFAX
UNION
SANDOVAL
MORA
HARDING
McKINLEY
LOS ALAMOS
SANTA FE
SAN MIGUEL
QUAY
VALENCIA
BERNALILLO
GUADALUPE
TORRANCE
CURRY
CATRON
SOCORRO
DE BACA
LINCOLN
ROOSEVELT
CHAVES
Detailed
in
fig. 30
SIERRA
OTERO
LEA
GRANT
EDDY
DONA ANA
HIDALGO
LUNA
CRAM'S
8½ x 11 Outline Map
NEW MEXICO
SCALE
MILES
COPYRIGHT
THE GEORGE F. CRAM COMPANY
INDIANAPOLIS
Longitude West of Greenwich

representatives of the forms are not found in the following counties: Harding, Luna, Grant, Hidalgo, Dona Ana, Sierra, McKinley, and San Juan. These counties may be divided into three groups. The first group has a sole member, Harding County. There appears to be no reason why the species should not occur here; perhaps a more thorough survey in this area will show the forms to be present.

The second group of counties, Hidalgo, Grant, Luna, Dona Ana, and Sierra, are located in the southwestern portion of the state. While in this area the mean average temperature and soil conditions are agreeable to _Ratibida_, the average rainfall is not sufficient for survival.

For the third group of counties, San Juan, McKinley, and the western areas of Rio Arriba and Sandoval, another explanation is probable. The environment is favorable for the growth of the species in these areas, but they are not reported there. Apparently mountains form a geographic barrier that serves to isolate this area. At the present time _Ratibida_ appears to be spreading through these mountains and at some future date may expand into this northwestern area.

Ratibida columnifera pulcherrima probably entered New Mexico from the southeast where there are numerous pure populations of the forms. _Ratibida columnifera_ representatives of the forms [illegible] found in the following counties: Harding, Luna, [illegible], Hidalgo, Dona Ana, Sierra, McKinley, and San Juan. These counties may be divided into three groups. The first group, a single member, Harding Co. [illegible]. There appears no [illegible] reason why the species should not occur here, [illegible] a more thorough survey in this area will show the forms to be present.

The second group of counties, Hidalgo, Luna, Luna, Dona Ana, and Sierra, are located in the south-western portion of the state. While in this area the mean average temperature and soil conditions are favorable to [illegible], the average rainfall is [illegible] for survival.

For the third group of counties, [illegible], McKinley, and the western edge of [illegible] and Sandoval, another explanation is offered. The environment is favorable for the growth of the [illegible] in these areas, but they are not [illegible] there. [illegible] mountains form a geographic barrier [illegible] to isolate this area. [illegible] to be spreading through these [illegible] at some future date may [illegible] the area.

[illegible] New Mexico from the counties where it was found, [illegible] pure populations of the forms. [illegible]

<u>pulcherrima</u> spread in a northeast sweep to the Sacramento Mountains which at the present time have numerous pure populations. <u>Ratibida</u> <u>columnifera</u> <u>pulcherrima</u> has just penetrated west of this range.

The evidence is that <u>R</u>. <u>columnifera</u> <u>columnifera</u> has entered the state from the northeast and the larger pure populations are found here. The western expansion of this variety was limited by the large number of mountain ranges in the northern part of New Mexico which serve as temporary barriers. <u>Ratibida</u> <u>columnifera</u> <u>columnifera</u> spread southward, hybridizing with <u>R</u>. <u>columnifera</u> <u>pulcherrima</u> in the central areas of the state where the two varieties met.

The pure populations seem to follow the contour of the mountain ranges. The populations of <u>R</u>. <u>columnifera</u> <u>columnifera</u> would appear to be running along the north-south canyons because of their southwestern migration through the state. On the other hand, populations of <u>R</u>. <u>columnifera</u> <u>pulcherrima</u> would appear along the east-west canyons since they are apparently migrating toward the northwest area of the state. The region of greatest hybridization in New Mexico is in the Lincoln National Forest. Hybrids appear in greater numbers in the area where the north-south canyons intersect in the east-west canyons. (See the map in fig. 29.)

Pollen fertility was determined for the parents and putative hybrids, and the results are recorded in Table I. The conclusion that may be drawn from the results of this table is apparent. There is no significant loss of fertility in the purple-yellow hybrid plants when compared with the parental _R_. _columnifera columnifera_ and _R_. _columnifera pulcherrima_.

Morphological differences between the two entities appear to be lacking. They can, however, be separated on the basis of ligule color. _Ratibida columnifera columnifera_ has yellow ligules while in _R_. _columnifera pulcherrima_ the ligules are purple. According to Morrow (1927, p. 325), anthocyanin pigments produce the purple color in the ligules. Upon standing, anthocyanin pigments break down in a neutral alcohol solution and, therefore, lose their color by conversion to the colorless isomer. With the addition of dilute acids, the anthocyanin can be stabilized in the form of the colored isomer. The yellow pigment is produced by the presence of xanthophylls. This pigment is an intra-cellular glucoside, which was found to be only slightly soluble in an alcoholic or aqueous solution. Xanthophylls were found to be of maximum color intensity and most soluble in an acid environment. It can be noted that the index of absorption and the ratio of the two pigments are directly proportional (see fig. 30). This would seem to

indicate that the colors are inherited quantitatively.

The color of the natural hybrids studied here can best be explained by the multiple factor hypothesis. There is an absence of sharp, easily definable classes of hybrid types. The absence of distinct groups is the chief characteristic of quantitative inheritance (Sinnott _et_ _al_., 1950, p. 122).

Representative patterns can be used as a basis for arbitrarily classifying color variation of the ligules of _R_. _columnifera_ _columnifera_, _R_. _columnifera_ _pulcherrima_, and their hybrids. The following Table II may be utilized for this purpose.

In _Rudbeckia_, which is closely related to _Ratibida_, Blakeslee found (fide Sinnott _et_ _al_., 1950, p. 105) a chemical method of distinguishing genetic types of yellow cones of _Rudbeckia_ _hirta_. In _Rudbeckia_ _hirta_ the yellow in the cones evidently results from chemically different processes than does the purple in the cones. The hybrids resulting from a cross between one type of yellow cone plant with another were purple. Therefore hybrids carried the reaction to a further stage (purple) than was possible by the parent possessing only one factor. Cases of interaction such as this, in which two genes are similar in individual effects but produce a totally new effect when together, are caused

by complementary genes. These genes may be modified by the genotype in which they appear. Such a situation may be responsible for some of the variation in the hybrid swarms of Ratibida. For example, sample numbers one and two (fig. 30) appear to possess more pigment than the parent R. columnifera pulcherrima.

The main purpose of this study was to obtain additional data concerning the taxonomic status of R. columnifera pulcherrima and R. columnifera columnifera. The two taxa occupy different ranges in New Mexico. However, highly variable natural populations consisting of parents and hybrid swarms occur where the geographic boundaries of the taxa overlap. Anderson (1952, p. 101) found much the same situation in Tradescantia and the domesticated avocado. So long as diverging taxa are able to hybridize naturally and merge back into a single population, they are not reproductively isolated, hence are not independent species. Varieties, like species, may carry different gene complexes which best fit them to survive in their different habitats. Ratibida columnifera columnifera and R. columnifera pulcherrima show different habitat preferences. Genetic differences also manifest themselves in color differences; hence there is justification for characterizing them as forms by visible external characteristics. The writer by complementary genes. These genes may be modified by the genotype in which they appear. Such a situation may be responsible for some of the variation in the hybrid swarms of Ratibida. For example, single numbers one and two (fig. 50) appear to possess more pigment than the parent R. columnifera pulcherrima.

The main purpose of this study was to obtain additional data concerning the taxonomic status of R. columnifera pulcherrima and R. columnifera columnifera. The two taxa occupy different ranges in New Mexico. However, highly variable natural populations consisting of parents and hybrid swarms occur where the geographic boundaries of the taxa overlap. Anderson (1949, p. 13) found much the same situation in Tradescantia and the domesticated avocado. So long as diverging taxa are able to hybridize naturally and merge each into a single population, they are not reproductively isolated, hence are not independent species. Varieties, like species, may carry different gene complexes which best fit them to survive in their different habitats. Ratibida columnifera columnifera and R. columnifera pulcherrima show different habitat preferences. Genetic differences also manifest themselves in color differences; hence there is justification for characterizing them as races by visible external characteristics. The nature therefore believes that R. columnifera columnifera and R. columnifera pulcherrima are valid varieties.

Table I. Fertility of Parental Species and Putative Hybrids

Accession no.	Ligule color	Percentage of stainable pollen
R3x1	mixed	95
R1x15	mixed	96
R3x2	mixed	96
R2x17	purple	96
R2x4	purple	97
R1x2	yellow	95
R6x10	yellow	96

Figure 29

Distribution of *Ratibida columnifera columnifera*, *Ratibida columnifera pulcherrima*, and their hybrids in the Lincoln National Forest

Key

- o *R. columnifera columnifera*
- ● *R. columnifera pulcherrima*
- x Hybrids

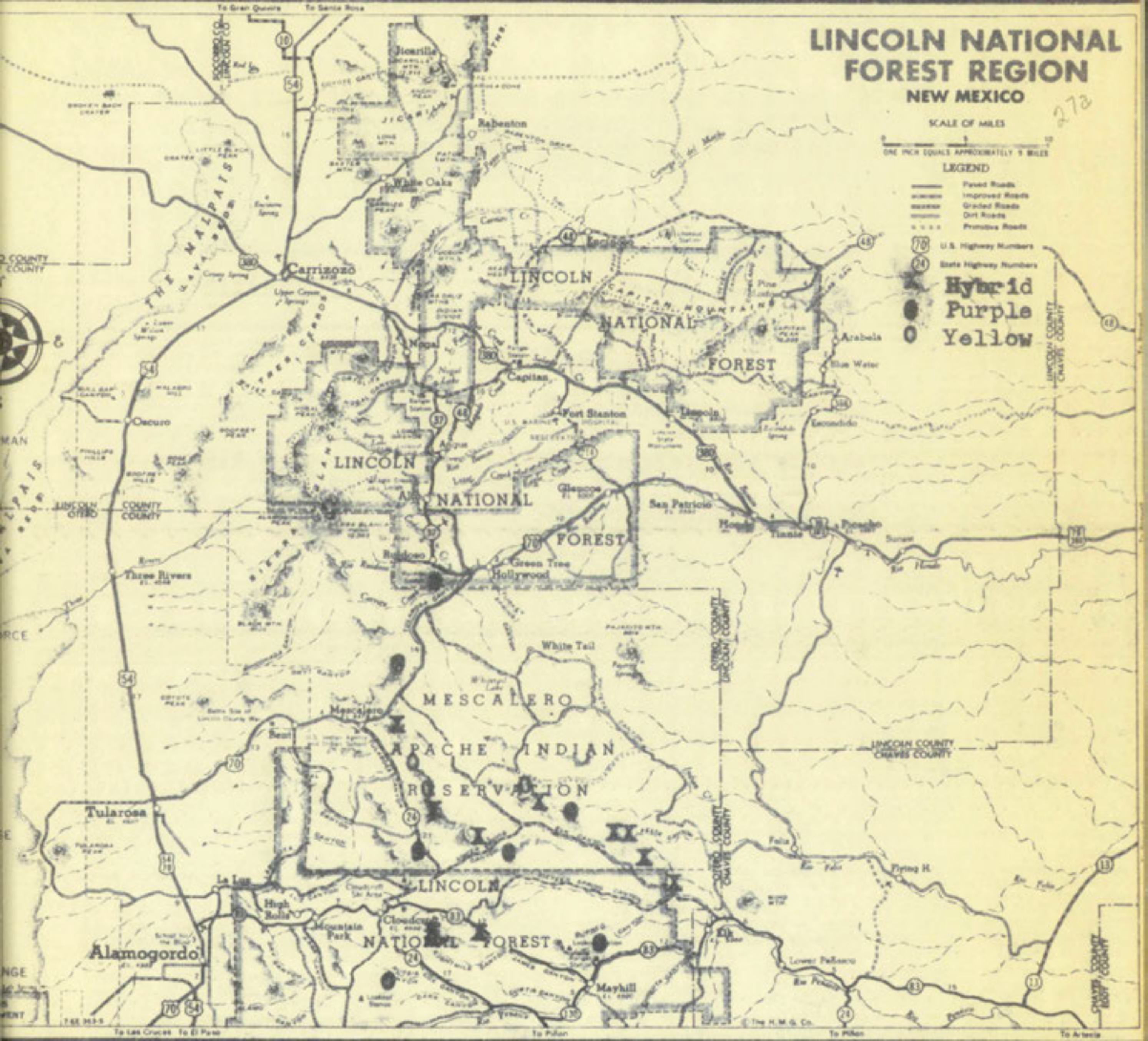
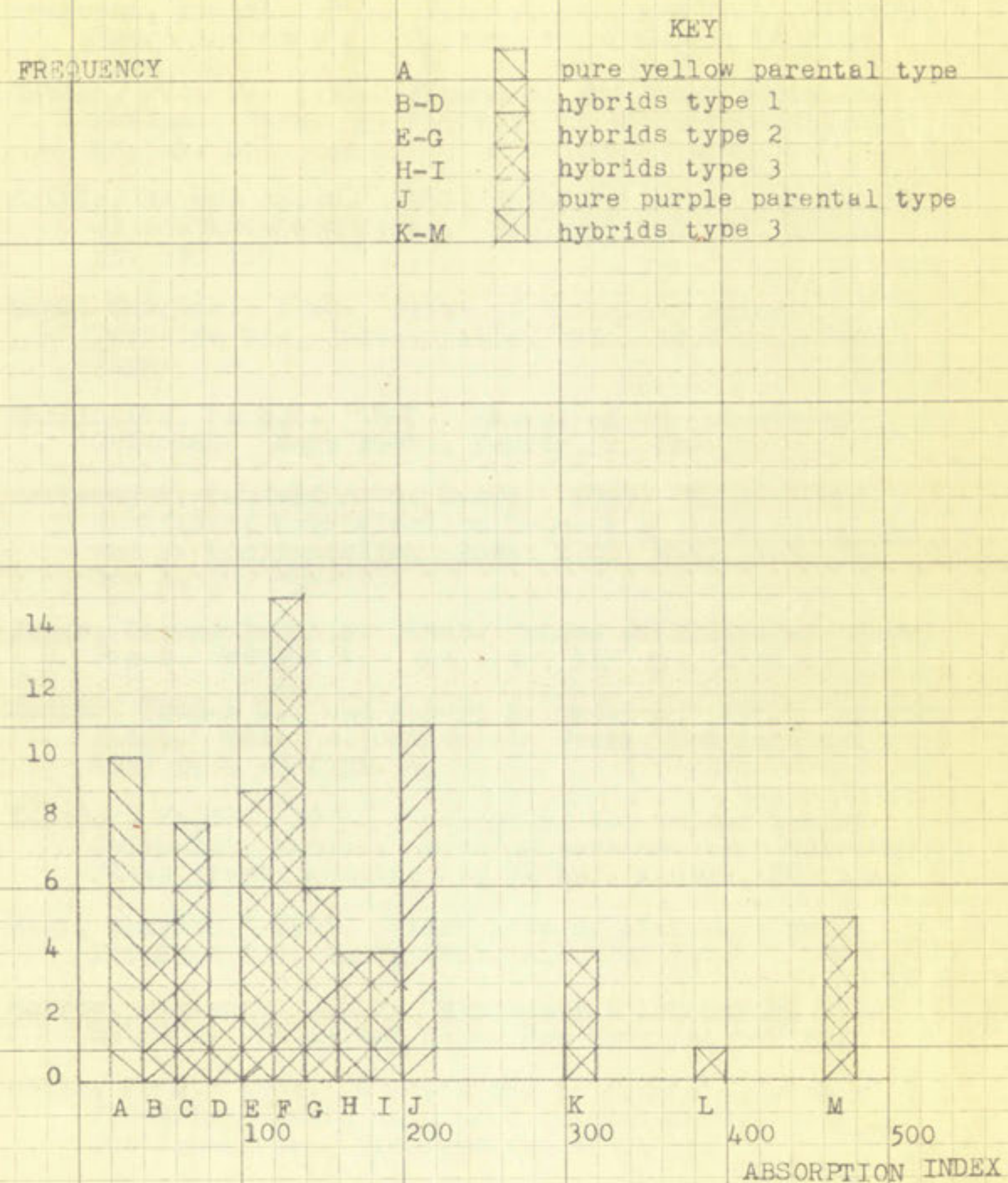

LINCOLN NATIONAL
FOREST REGION
NEW MEXICO
27a
SCALE OF MILES
ONE INCH EQUALS APPROXIMATELY 9 MILES
LEGEND
Paved Roads
Improved Roads
Graded Roads
Dirt Roads
Primitive Roads
U.S. Highway Numbers
State Highway Numbers
X Hybrid
Purple
O Yellow
To Gran Quivira
To Santa Rosa
Jicarilla
Rabenton
White Oaks
Carrizozo
THE MALPAIS
Nogal
Capitan
LINCOLN
NATIONAL
FOREST
CAPITAN MOUNTAINS
Arabela
Blue Water
Lincoln
Fort Stanton
Escondido
Oscuro
Glencoe
San Patricio
Hondo
Tinnie
Picacho
Ruidoso
Green Tree
Hollywood
Three Rivers
LINCOLN COUNTY
OTERO COUNTY
White Tail
MESCALERO
APACHE INDIAN
RESERVATION
Mescalero
Bent
Tularosa
La Luz
High Rolls
Mountain Park
Cloudcroft
LINCOLN
NATIONAL FOREST
Alamogordo
Mayhill
Elk
Lower Peñasco
Flying H
LINCOLN COUNTY
CHAVES COUNTY
OTERO COUNTY
LINCOLN COUNTY
To Las Cruces
To El Paso
To Piñon
To Artesia
The H.M.G. Co.

Table II. Classification of ligules of *Ratibida columnifera columnifera*, *Ratibida columnifera pulcherrima*, and their hybrids according to color patterns

Classes	Color Ratio
I	100% yellow
II	25% purple; 75% yellow
III	50% purple; 50% yellow
IV	75% purple; 25% yellow
V	100% purple

Figure 30

Graphic relationship of the hybrids to the parental types with regard to relative quantities of purple and yellow pigments: 10 yellow, 11 purple, and 70 putative hybrids


KEY
FREQUENCY
A pure yellow parental type
B-D hybrids type 1
E-G hybrids type 2
H-I hybrids type 3
J pure purple parental type
K-M hybrids type 3
14
12
10
8
6
4
2
0
A B C D E F G H I J
K
L
M
100
200
300
400
500
ABSORPTION INDEX

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