THE GRASS GENERA ORCUTTIA AND NEOSTAPFIA: A STUDY IN HABITAT AND MORPHOLOGICAL SPECIALIZATION

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Without a doubt, the endemic genera *Orcuttia* and *Neostapfia* are the most unusual and rarest of the California grasses. *Orcuttia* comprises five species and two varieties, while *Neostapfia* is monotypic. All are narrowly restricted annuals which develop in the summer beds of vernal pools and exhibit peculiar morphological features. Their relationship to other grasses is not apparent and quite likely they represent a relict group, the ancestors of which are unknown. Very few collections of them had been made up to the time Hoover (3) made known the degree of speciation and geographical range of the *Orcuttia* species. A relatively small number of these grasses has been collected since.

In cooperation with the Department of Agronomy, University of California, Davis, and its grass research program, the author was privileged to spend part of the summer of 1958 observing the nature of the habitat and making extensive collections of these fascinating grasses. The results were very gratifying, and the success of this specialized exploration has prompted the author to present his findings and to provide additional information about the habit, habitat, and morphological development of these two unique genera in the California grass flora.

The author is especially grateful for the helpful suggestions and criticisms by Dr. G. L. Stebbins, Department of Genetics, and Dr. Jack Major, Department of Botany, both of the Davis campus, University of California.

I. The Nature of the Habitat

While many of the Californian grasses are relatively unspecialized as to habitat, *Orcuttia* and *Neostapfia* are restricted to vernal pools. These basins, sometimes called "hog wallows," are best developed on the rolling plains surrounding the Great Valley of California, and to a lesser extent on the valley floor. Rainwater collects in them and stagnates during the winter and spring, and by late spring or early summer it has completely evaporated. The pools are quite variable in extent or area, depending upon the terrain. Some are small, shallow, or circular to irregular shape, and several meters in diameter. Others may be greatly ramified, with numerous islands, while some are quite large, perhaps 500 meters or more in diameter, being then classed as intermittent lakes.

Upon evaporation, the recession of the water from the margin initiates development of a unique flora on the muddy strand. Some plant species, however, depend upon the standing water for seedling development or renewal of perennial growth. It is not unusual to find mature annuals on the margins of the pools, while very young plants of the same species are in active growth at the edge of the receding water. Such annual plants

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as *Allocarya, Pogogyne, Downingia,* and *Navarretia* often show this pattern and become generally distributed over the beds. The grasses, *Deschampsia danthonioides* and *Hordeum hystrix,* are restricted to the margins. Of the perennials, *Eryngium* may be generally distributed or marginal, while *Eleocharis palustris, Marsilea,* and sometimes *Damasonium* are in the central or deeper portions of the basins. The distribution or occurrence of any one plant species in this environment is quite dependent upon size, depth, and soil type of the pool and the length of time of standing water.

Orcuttia and *Neostapfia* require a very special type of vernal pool. The concept of "hog-wallow" should be amended to "elephant-wallow" to satisfy the environmental demands of these grasses. Primarily, the optimum size of their vernal basins is about 20–100 meters or more in diameter or length. Secondly, such basins must neither be drained naturally nor artificially, for long periods of standing water are a necessity. Dry, unfavorable years result in a paucity of the grasses, while years of heavy rainfall such as 1958 (Table 1) are responsible for their peak development. The best stands of either *Orcuttia* or *Neostapfia* occur mostly in the absence of other vegetation (fig. 1E). The adobe muds in the large vernal pools, with their barren, dried, cracked, and often well trampled surfaces, are ideal sites. The presence of the ubiquitous vernal pool *Eryngium vaseyi* and the sedge, *Eleocharis palustris,* restricts the density of *Orcuttia* and *Neostapfia.* Any dense stand of either of these perennials has relatively few to none of the annual grasses among them. Barren areas or clearings in *Eleocharis* and thin stands or absence of the *Eryngium* become excellent sites for *Orcuttia* development. *Marsilea* apparently has no deterrent effect on the grasses, as it is a frequent associate of them. Relatively few annuals offer competition to *Orcuttia* or *Neostapfia, Boisduvalia* being probably the commonest, with occasionally *Eremocarpus* and certain *Euphorbia* species, but in the main most annuals have dried before maximum development of the grasses occurs.

Recognition of the proper habitat of *Orcuttia* and *Neostapfia* simplifies collection of these unusual grasses. The most numerous, shallow, early drying vernal pools can thus be eliminated as sites for their occurrence, and only the large-type pool, with some barren portions, need be considered.

In the past evolutionary history, *Orcuttia* and *Neostapfia* probably developed as shore or strand grasses on the margin of a sea, such as once covered the present Great Valley area. The conversion of the sea to a land surface involved only minor modification in the character of the habitat so that isolated ponds, developing along the shore of the receding sea, became an eventual refuge for these grasses. Perhaps the greatest change came in elimination of salts, yet *Neostapfia* has been found growing on alkali in Colusa (the type locality) and Solano counties. *Orcuttia mucronata* occurs, as far as is known, only on alkali, but other species of the genus favor nearly neutral or perhaps slightly acid soils. It also became

necessary for the plants to withstand the period of summer dryness as developed in the Great Valley and surrounding areas during the geologic changes.

II. The Areas of Collection

The pioneer work by Hoover (3) established geographical ranges for the species of *Orcuttia* and enabled the present writer to visit several areas of known occurrence of these narrow endemics. Aside from studying habitats and associations, extensive collections were made of all species except *Orcuttia californica,* which occurs only in southern California.

A. The San Joaquin Valley

1. Stanislaus County. The low hill and rolling plain areas bordering the Tuolumne River east of Waterford and Hickman, are especially rich in *Orcuttia* and *Neostapfia*. The topography favors development of the larger-type vernal pool. In this region the upland soils are primarily a reddish loam of the San Joaquin series, while the pool beds are light to dark grey adobe of the Alamo series, well permeated with iron compounds which act as cementing materials. Most of the land is grain-farmed, some exists as dry rangeland, while other areas have been converted to irrigated pasture.

In the grainfields between the southern part of Modesto Lake and State Highway 132, there are seven large vernal pools bordering on Dienstag and Reservoir roads. All but one of these basins had excellent stands of *Neostapfia,* four of them with abundant *Orcuttia pilosa,* and a single one with *Orcuttia californica* var. *inaequalis*. Hoover apparently overlooked this particular area of *Orcuttia* and *Neostapfia* while collecting in 1936–1938. The type locality for his *Orcuttia pilosa* lies five miles farther east, the region, as far as determinable, now being irrigated pasture.

Two vernal basins border Dienstag road, the southern one unequally divided by the gravel roadbed (fig. 1-A). The larger and western section of this latter pool is about 100 meters across at the widest point and nearly 125 meters long. Its basin was entirely covered by a magnificent, dense stand of *Neostapfia* (fig. 1-B). A few scattered clumps of *Eleocharis palustris* and *Sida hederacea* were found along the fence adjacent to the road, otherwise there was pure *Neostafia*. The green "sheet" of this grass was in marked contrast to the dry barley stubble on the surrounding slopes.

The eastern and smaller portion of this vernal pool is bordered by hilly rangeland. At the lowest point, near the road, there was still some standing water on July 28, 1958 (fig. 1-A). Surrounding the murky water, in a semicircle, was a wide band of barren, dark-grey, well-trampled mud. On the periphery of the mud, a pale green band of *Neostapfia* was developing on the cracking, drying, grey adobe. Several resident dairy heifers were intermittently, but actively grazing the grass!

The second vernal pool along Dienstag road is about 100–125 meters long and perhaps 75 meters wide. The bed was a solid stand of *Neostapfia*

with an abundance of *Orcuttia pilosa* along the margin. This unique pattern invariably occurred whenever the two grasses were associated.

Three vernal pools along and south of Reservoir Road were replete with *Neostapfia* and *Orcuttia pilosa* as the sole or major occupants. One pool, however, contained mostly *Orcuttia californica* var. *inaequalis,* very little *Orcuttia pilosa,* and no *Neostapfia.* Another pool was of unique shape, nearly 150 meters long and about 10 meters wide, its bed a pure, solid stand of *Neostapfia.*

The barley field operations in this area apparently do not affect the successful development of these peculiar grasses in their habitat. Undoubtedly the planting machinery disturbs the vernal pool beds in the fall, yet after that they remain undisturbed until harvest, at which time *Orcuttia* and *Neostapfia* are reaching maximum development.

A large playa, about 150 meters or so in diameter, is situated in a small valley leading out of the hilly country three miles east of Hickman. Though the surrounding areas are grain-farmed, the vegetation of this bed differs considerably from those of the previous area. *Neostapfia* is restricted to small patches, while *Orcuttia californica* var. *inaequalis* is more widely dispersed. Active competition is afforded by *Centromadia fitchii, Boisduvalia,* and *Eryngium,* with an abundance of dried *Allocarya, Downingia,* and *Navarretia leucocephala.* The more barren areas on the dried and cracked lead-grey adobe support the best stands of both *Orcuttia* and *Neostapfia.*

An extensive reservoir or permanent lake[1] (fig. 1-C) is located on the Loren Rouse Ranch six to seven miles east of Hickman, along the road to La Grange. *Neostapfia* and *Orcuttia pilosa* occur abundantly along the strand, which is subject to vernal flooding and summer drying. This lake has quite likely been developed from a large vernal playa which originally was populated by these two grasses, since the margins of man-made reservoirs are not ordinarily sites for development of either of these grass genera. If planted, they might very well become adapted to reservoir strands.

Summer fallowing of the hilly grainland to the south had closely approached, nevertheless had not disturbed the strand. Dry rangeland and irrigated pasture surround the lake on the north and east, respectively, though neither operation had disturbed the habitat.

The old Paulsell warehouse is located along the old Sierra railroad northeast of Waterford. The land area is now largely devoted to irrigated pastures except for the hilly, dry rangeland to the north. The distinctive *Orcuttia greenei* was found in a large, undisturbed playa at the southwestern base of a prominent knob-like hill. The playa basin is perhaps 200–250 meters in diameter and composed of black, deeply-cracked adobe. Aside from the dense, dried *Allocarya* cover, *Eryngium* and *Eremocarpus* were dominant, with some *Eleocharis palustris* and *Boisduvalia.*

[1] Since the above was written, it has been learned that this is a natural pool.

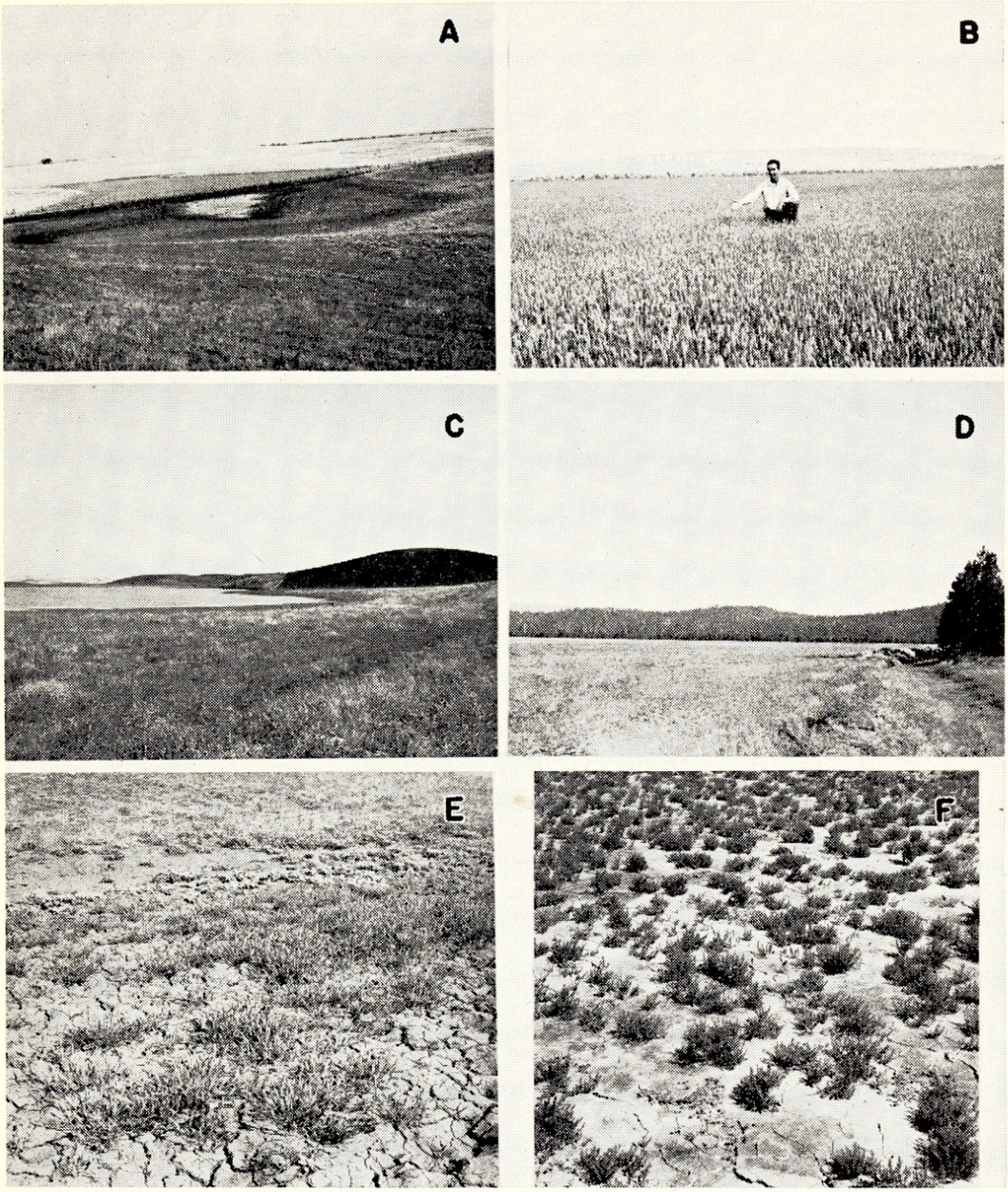

FIG. 1. The habitats of *Orcuttia* and *Neostapfia*. (A) Large vernal pool in the barley-farmed area south of Modesto Lake, east of Waterford, Stanislaus County. Dienstag Road divides the basin. (B) The author in the solid stand of *Neostapfia* present in the far portion of A. (C) Lake on the Rouse Ranch east of Hickman, Stanislaus County, the strand of which has an abundance of *Neostapfia* and *Orcuttia pilosa*. (D) Goose Valley, Shasta County, the type locality of *Orcuttia tenuis*. The author collected the grass in the ditchbed at the right. (E) *Neostapfia* growing on a typical soil of a vernal pool bed. Note the cracks and absence of other vegetation. *Eremocarpus* lines the bed in the background. (F) Habitat of *Orcuttia mucronata*. *Frankenia* and the prostrate *Eryngium aristulatum* are the only associates.

The *Orcuttia* was not abundant, but occurred mostly as scattered plants in areas containing the least *Eryngium* and *Eremocarpus*.

2. Merced County. In the vicinity of the old Ryer station, located 6.5 miles south of Montpelier, there are two large-type vernal pools containing *Orcuttia californica* var. *inaequalis*. The rather uniform rolling hill country in this area is all grain-farmed, with rather numerous, smaller-type vernal pools. The large playa to the west is basically a lead-grey colored adobe, well populated with *Centromadia fitchii, Centromadia pungens, Sida hederacea, Boisduvalia* and marginal *Eryngium* as well as the dried *Allocarya, Downingia* and *Navarretia leucocephala*. The *Orcuttia* was most abundant in areas of the least competition.

The eastern vernal pool harbored a dense stand of *Orcuttia californica* var. *inaequalis* to the near exclusion of other plants. Apparently the basin had been completely cultivated during barley planting, for faint furrows were evident over the pool bed. The *Orcuttia* was exceedingly robust, some of the plants being 12–15 cm. high and with as many as 60 culms, a development far in excess of those in the neighboring playa. Aside from dried *Allocarya,* only a few scattered plants of *Centromadia* and *Eremocarpus* were present.

North of Legrand, in typical rolling plain rangeland, is a large playa perhaps 300–350 meters in diameter. The soil of the basin is a black adobe, becoming exceedingly deeply cracked when dry. Some of the cracks extended from three-fourths to nearly a meter in depth and from 5–10 cm. across at their aperture. A dense stand of *Eremocarpus* covered the major portion of the bed, the whole appearing from a distance as a silver-grey "lake." Large specimens of *Orcuttia greenei* were numerous in areas of the least *Eremocarpus,* though scattered individuals occurred throughout the playa. *Boisduvalia* was perhaps the closest and only other associate.

B. The Sacramento Valley and Northern California

1. Solano County. A magnificent alkaline, intermittent lake is situated in a rolling plain area twelve miles south of Dixon, Solano County. It is shallow, has no drainage, and is about 500 meters in diameter. The predominant vegetation in the lake basin is *Frankenia grandifolia, Cressa truxillensis, Sida hederacea* and *Eryngium aristulatum,* with some patches of *Eleocharis palustris*. The marginal strand is largely *Distichlis, Lippia* and *Navarretia bakeri*. The dried crust varies from a uniform, glaring-white pavement to a tan and cracked surface. On the latter type, *Neostapfia* and an undescribed species of *Orcuttia* grew in association with *Frankenia* and *Eryngium* (fig. 1-F). Both grasses, at their best, were rare occupying an exceedingly small area of about 15–20 meters in diameter. The *Orcuttia* will be described later in this paper as *Orcuttia mucronata,* while the occurrence of *Neostapfia* here represents a new area for California.

2. Sacramento County. According to Hoover (3), *Orcuttia californica* var. *viscida* is not known to occur outside of Sacramento County. The Orangevale area now shows a distinct waning of the grass, and in all probability the habitat will be eliminated by residential development.

On the higher, rolling plains north of Sloughhouse, one large vernal pool and several smaller, but deep ones, support fairly good stands of this attractive *Orcuttia* and represent its type locality. It was conspicuous along the margins and in some parts of the bed of the large pool. This greater basin, 100 or more meters in length and with some ramification, is largely a barren and stony bed. The cracked, lead-grey, adobe soil is well supplied with iron concretions, apparently an indication of the type of soil several *Orcuttia* species prefer. Some patches of *Eleocharis palustris* and *Eryngium* were present, but these species were certainly not diffuse in any area of the pool.

3. Butte County. A single vernal pool on the rolling plains about ten miles southeast of Chico was well supplied with *Orcuttia greenei* and probably represents the type locality of this species. The basin, 75–100 meters in diameter, is composed of a grey-black, crumbly, stony, and pebbly soil. Over the major portion of the pool the marginal vegetation of *Eryngium* and *Eremocarpus* gave way to an abundance of the *Orcuttia* and to the prostrate annual *Euphorbia hooveri.*

4. Tehama County. *Orcuttia tenuis* is endemic to northern California, preferring soils probably derived from volcanic substrates. Only certain areas of Tehama, Shasta, and Lake counties have the proper environmental conditions, each of them in entirely different settings.

In Tehama County, on a rocky, volcanic plateau eleven miles northeast of Red Bluff, lies an extensive dry lake known as Hog Lake. The basin is perhaps 300 meters wide and 1500 meters long, surrounded by mixed, open grassland and blueoak woodland. The western shallow portion and the marginal strand were largely populated by *Eryngium,* while the deeper portions contained *Eleocharis palustris* and *Damasonium.* The best development of *Orcuttia tenuis* occurred in the barren, stony areas among patches of the *Eleocharis* and to a lesser extent *Damasonium.* Although the grass was rather uniformly distributed among *Eryngium,* it had dried too quickly here for proper seed set. The dried, leached grass stood in marked contrast to the grey-green plants in anthesis and fruit maturation which occurred in the deeper and barren areas of the lake basin.

5. Shasta County. *Orcuttia tenuis* occurs in abundance in a series of vernal pools around the Redding Municipal airport three to five miles north of Anderson, the area being known as Stillwater Plains. The southern series is largely in open grassland, while those to the west and north of the airport are surrounded by oak, digger-pine, and manzanita. The typical floristic association pattern of all of the pools can be illustrated by that in a single pool, a circular basin about 125 meters in diameter. Here *Eryngium* is marginal, but the majority of the bed contains *Eleocharis palustris* with intermittent patches of *Marsilea.* Although some of

the *Orcuttia* grew among the sedge, it was more common in the barren situations. None of the grass could be found among the *Eryngium*.

Two shallow and smaller pools associated with the open grassland had evidently dried too quickly, for the grass was leached and the spikelets were without seed. A small but deep ditch along the road and continuous with one of these basins contained green and properly maturing *Orcuttia*.

The type locality of *Orcuttia tenuis* is Goose Valley, north of Burney, Shasta County. The type collection was made here by Alice Eastwood in 1912, and since that time no other collections are known to have been made. This mountain valley is around 3500 feet in elevation, surrounded by mixed conifer forest, and is primarily meadowland with some dry-lake habitats in the northern section. Most of the valley is now largely cultivated, either as permanent pasture or cropland. A series of canals which effectively drain many areas is consequently disastrous to the survival of the *Orcuttia*. Fortunately, the grass was located in the nearly barren bed of an old ditch skirting a northeast portion of the valley (fig. 1-D). Aside from small patches of *Eleocharis palustris* and *Damasonium* along the edges, and some scattered *Downingia* and *Boisduvalia* in the bed, *Orcuttia tenuis* remained the dominant plant of the basin.

6. Lake County. The occurrence of *Orcuttia tenuis* in the Coast Ranges was first made known by Milo Baker, eminent Santa Rosa botanist, who collected the grass on the north shore of Bogg's Lake, Lake County. This lake is situated in a yellow pine forest flat on the northwest slope of Mount Hannah. The basin is around 1650 meters in diameter, contains water the year round, yet is provided with an adequate strand for the development of many unique and unusual plants.

A visit to the lake in August, 1958, proved disappointing because of the high water level and resultant flooded strand. Previous to 1958 the author had collected the grass on the southwest margin among *Eleocharis palustris* and *Eryngium* though it was exceedingly rare, requiring considerable search to locate perhaps two dozen plants.

III. Yearly Fluctuations in Abundance

The year 1958 was an ideal one for maximum development in the stands of *Orcuttia* and *Neostapfia*. In all of the areas visited, with one exception, these grasses were abundant, the most remarkable being the magnificent stand of *Neostapfia* just south of Modesto Lake.

What of other years? Even though the grasses must, in the overall floristic analysis, be regarded as rare and narrowly restricted endemics, why have they not been collected more often? The answer undoubtedly lies in their fluctuations in abundance from year to year. Unfavorable, dry years would be associated with poor development or scattered stands and earlier maturity. A shallow depth of water evaporating rapidly during the spring might prove quite disastrous to the annual stand of the grasses, even though they are situated in the required habitat. Such an environmental stress would antagonize the genetically-fixed, summer-

maturation character of *Orcuttia* and *Neostapfia,* resulting in heavy seedling mortality and consequent rarity of plants in the habitat. Furthermore, supposing good germination in water or on the mud of the vernal basins, too rapid a drying might cause premature flowering and poor to no seed set.

How, then, is perpetuation of the grasses maintained over unfavorable periods? Presumably the large seed production effected in such a year as 1958 might be adequate for the next several years, since there is a suggestion that the seed remain viable over many years and that a prolonged period of dormancy may be necessary before germination occurs. This supposition is drawn, but perhaps too hastily, from an attempt to germinate *Orcuttia* seed. *Orcuttia pilosa* grains collected in August, 1957, were placed on a blotter in a petri dish on January 31, 1958, kept at room temperature, and under continuous moisture. By September 1, 1958, no germination had occurred, though very few of them had succumbed to mold. Aside from the moisture, this artificial medium lacks all of the elements of the natural ones.

TABLE 1. Annual Precipitation (July to June) of four reporting stations in the Great Valley of California*

Season	Merced	Modesto	Sacramento	Red Bluff
1931–1952 (average)	12.35	12.44	16.68	23.15
1955–1956	15.42	15.62	25.53	28.53
1956–1957	7.40	8.63	13.78	12.25
1957–1958	25.63	23.04	28.70	38.03

* Data obtained from USDA Weather Bureau-Climatological Data, California section.

Table 1 shows some climatological data for most of the areas where the writer collected *Neostapfia* and *Orcuttia* in 1958. The amount of rainfall during the 1957–1958 season supports the argument that abundance of the two grass genera is dependent on the amount of precipitation. In all probability there was generally minimum development of the grasses during the 1956–1957 season. Dr. G. L. Stebbins, department of Genetics, and Dr. and Mrs. Louis Mann, department of Vegetable Crops, University of California, Davis campus, visited the vernal pool as shown in Figure 1-A, in the latter part of June 1957. They could scarcely find any *Neostapfia,* and what few plants were found were thoroughly dried and mostly dessicated. The remarkable solid stand of the grass present in July, 1958, could not have developed from the 1957 crop. Undoubtedly a larger seed crop had been produced in previous and more optimum years.

Without doubt, judging by observation of the excellent stands of both grass genera in 1958, the amount of rainfall and consequent depth of standing water in the vernal pools is most critical in their life cycle and reflects their yearly abundance.

The collections by Hoover (3) and others have pretty well established the geographical range of the *Orcuttia* species and *Neostapfia.* It remains

to round out their distribution by detailed collections of the two genera from year to year.

The primary purpose of this paper has been to stimulate interest in these most unusual and scientifically interesting grasses and make known their specific type of habitat and specific locations. The progress or decline of the grasses in any one area can be evaluated by the frequency of collection. This concern by the author is not without foundation. With the steady increase in California's population and with the resulting modified land manipulation that must occur, there is a good possibility of the destruction of many habitats, and this may result in the extinction of these grass species or their varieties.

FIG. 2. *Orcuttia mucronata* sp. nov. Plant from type specimen, approximately natural size.

IV. AN UNDESCRIBED SPECIES OF ORCUTTIA

The extensive collections of *Orcuttia* and *Neostapfia* made during July and August, 1958, uncovered a most unusual and distinctive *Orcuttia* species on the western side of the lower Sacramento Valley. The grass differs rather considerably from most other *Orcuttia* species, and a more radical treatment might erect a new genus. However, until all details of the plant can be evaluated it seems expedient to assign the grass to *Orcuttia*.

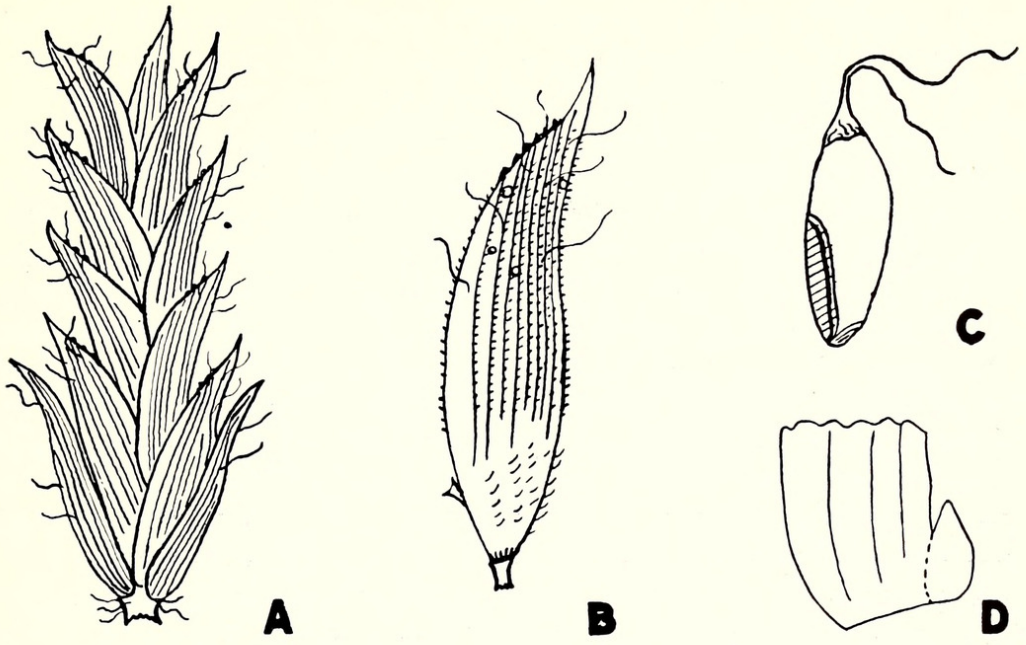

FIG. 3. *Orcuttia mucronata* sp. nov. (A) spikelet, × 5.5. (B) floret, × 7.3. (C) caryopsis, × 7.3. (D) lodicule fused to the palea, × 18.

Orcuttia mucronata sp. nov.

Planta annua aestivalis aromatica flavoviridis folia rigida extrinsecus curvata 1–4 cm. longa inflorescentia racemiformis basi tantum inclusa spiculis 7–19 spiralibus 5–10 floribus nec supra nec infra glumas disarticulantibus lemmis 5–7 mm. longis apice mucro unico terminatis dentibus lateralibus suppressis palea apice trilobata lobis dentatis lodiculis duabus hyalinis enervatis paleae adnatis.

Summer annual; pilose throughout, yellow-green, aromatic. Culms few to many, decumbent, 2.5–12 cm. high; leaves eligulate, viscid, 1–4 cm. long, somewhat rigid, curved outward tapering to a fine point; inflorescence a raceme, 1.5–6 cm. long, partially included, spikelets 7–19 in number, spirally arranged; spikelets 7–13 mm. long, 5–10-flowered, no disarticulation between the florets or below spikelet; glumes 4–7 mm. long, unequal, nearly approximate, lanceolate, the apex pilose, mostly awn-pointed or occasionally with 1 or 2 lateral teeth; lemmas coriaceous, 5–7 mm. long, the upper portion excurved, sparsely pilose, scabrous, viscid and light green, the lower portion short-hairy and whitish, the apex obtuse with a median mucro, 0.5 to nearly 1 mm. long, the lateral teeth suppressed, the margin appearing merely erose; palea shorter than the lemma, the apex 3-lobed, the lobes toothed, pubescent towards the margin near the apex; lodicules 2, fused to the palea, hyaline, nerveless, about 0.25 mm. wide and 0.5 mm. long; anthers yellow fading pinkish; caryopsis oblong, flattened, 3 mm. long, the embryo 1.5–2.0 mm. long along one side of the grain (figs. 2 and 3).

Type. Alkaline lake, 12 miles due south of Dixon, Solano County, California, August 1, 1958, *Crampton 5057,* AHUC. (Isotypes: UC, JEPS, DS, US, CAS, K.) Known only from a single dry lake at the type locality.

Other collections (*Crampton 5011, 5059, 5093,* and *5113*), all collected in this single locality, represent a series of developmental stages. *Orcuttia mucronata* is, at the most, rare. Only three patches of the grass, roughly 3–8 meters in diameter have been found over the large expanse of the lake bed. These small populations apparently occur in the deeper portions and on a cracked alkali with a brownish film over its surface. The white, smooth alkali pavement, characteristic of much of the lake harbored none of the grass. The soil type is classified as the Lindsey clay loam series. The soil survey of the Suisun area (1) indicates that the surface of this soil is a dull, dark or brownish grey material with a large proportion of fine to very fine sand. It deflocculates and when dry it becomes hard and baked. Organic matter is low, and most areas contain alkali. During the rainy season such areas become ponded for weeks or months at a time, the soil taking water slowly and having a high water-holding capacity. The surface layer extends from 8–10 inches in depth, and certain areas contain lime. The subsoil is heavy textured and compact, with some calcareous areas.

The soil at the area where the type plants of *Orcuttia mucronata* grow shows a pH of 8.0 on saturated paste as determined by the Agronomy Soils Laboratory.

V. Morphological Characteristics

The classical alliance of *Orcuttia* and *Neostapfia* to the tribe Festuceae, on the basis of gross spikelet morphology as outlined by Hitchcock and Chase (2), is inadequate in establishing relationship of the two genera to other grasses. A review of the salient features of both *Orcuttia* and *Neostapfia* indicates that they are not closely related to any members of the Festuceae.

One of the most conspicuous features of these grasses is the viscid secretion on all aerial parts of the plant whether young or mature. At first the secretion is glistening and watery, but towards maturity it becomes a thicker, denser, usually brownish exudate. In *Neostapfia,* distinctive scale-like raised glands on the lemma nerves and leaves contribute to the viscidity. In association with the copious secretion, a peculiar odor emanates from either fresh or dry material in any stage of development. The viscidity undoubtedly conserves plant moisture during the warm late spring and hot summer temperatures, while the aromatic habit may serve to reduce or repel animal depredation. In some of the collection areas grasshoppers were in abundance, but the green *Orcuttia* or *Neostapfia* plants were unaffected by the voracious insects.

In marked contrast to the Festuceae, *Orcuttia* and *Neostapfia* are summer-maturing annuals that occupy a highly specific type of habitat. Their coloration varies from a pale- to grey-green, and all are hairy. In

Neostapfia, however, hairs on the foliage are sparser, and very minute.

The nature of the foliage is distinctive, for in both genera there is no differentiation into sheath and blade, and consequently a true ligule and well-defined collar are absent. In all but *Neostapfia* and *Orcuttia mucronata* there is a definite abscission of the blade portion of the leaf. This deciduous character is not apparent until the leaves are dry, although in some instances the point of abscission is faintly visible in green tissue and might correspond to a "collar." The hairiness on the upper surface of the *Orcuttia* blades terminates abruptly at the fracture region, so that the resultant line of hairs might be construed as ligular. Otherwise the leaves of both genera loosely envelope the culms.

The culms of *Orcuttia* and *Neostapfia* are solid, the internodes being filled with pith. In the larger plants of *Neostapfia,* the decumbent culms form a zig-zag pattern, thereby providing additional support of the plant's superstructure. Branching is basal in all of the grasses except *Orcuttia tenuis,* which is literally "top-heavy." A single, filiform, culm, often with adventitious roots from the lower nodes, supports the entire ramification above, and when excessively branched the whole plant becomes decumbent.

The mature inflorescences in both genera are exserted, except for *Orcuttia mucronata,* which is partially included. *Neostapfia* has a cylindrical, spike-like panicle, the terminal portion differing from the rest of the rachis in bearing small, closely appressed, lanceolate bracts. In *Orcuttia* the inflorescences are spikes or racemes, the shape varying among the species. The spikes of *Orcuttia pilosa* and *Orcuttia tenuis* are more or less elongated, with mostly distichous spikelets. A spiral arrangement of spikelets exists in *Orcuttia greenei* and *Orcuttia mucronata,* with the inflorescence somewhat elongate. In *Orcuttia californica* var. *inaequalis* and *Orcuttia californica* var. *viscida* the spike is sub-capitate, with a secund arrangement of spikelets.

The spikelets in *Neostapfia* are most unusual. They are without glumes, and the florets are so arranged as to suggest a trimerous cluster of spikelets. The florets are secund, the two lower ones divergent, the three or four upper ones closely imbricate. Disarticulation normally occurs between the florets, but occasionally below the spikelets, the rachis being continuous. In *Orcuttia* the spikelets are solitary, the floret number variable from 5–10 in *Orcuttia mucronata* to 10–30-, or even 40 in other species. Except for *Orcuttia tenuis,* there is little or no disarticulation of the florets, the whole inflorescence largely non-shattering. The culms of *Orcuttia greenei* are excessively fragile at the base, and the mature seed heads are readily deposited upon the surface of, or cracks in, the adobe soil.

The form of the lemma apex is an excellent diagnostic character for both genera. Along with the form of the inflorescence, it is employed consistently in identification keys and will not be discussed here. The lemma texture in *Neostapfia* is papery except for the tough nerves, while the *Orcuttia* lemmas are coriaceous.

Mature grains of both genera were examined from the material collected during 1958. In common they show: a loose enclosure between the lemma and palea, lateral flattening with the embryo extending along one side, a large basal hilum, persistent style base at the apex, and compound starch grains in the endosperm. The *Neostapfia* grains are obovate, completely viscid, and dark brown in color. Those of *Orcuttia* are oblong, not or scarcely viscid, and the embryo and hilum are conspicuously brownish in contrast to the light-colored endosperm.

Lodicules are apparently absent in all except *Orcuttia mucronata,* and here their unique appearance (fig. 3-D) suggests that a sectional division should be made to accommodate this species in *Orcuttia*; or possibly the lodicules along with other characters suggest that generic rank is merited.

The similarity of habitats, growth habit, and convergence of some morphological features indicate a rather close relationship between *Orcuttia* and *Neostapfia,* while their affinity to other grasses is not readily apparent. They should be removed from the Festuceae and might well be considered as a separate tribe.

VI. Summary

1. *Orcuttia* and *Neostapfia* are restricted to a special type of vernal pool or "hog-wallow" which limits their geographic distribution. The association patterns of both *Orcuttia* and *Neostapfia* are truly remarkable and would constitute excellent material for detailed ecological studies. In certain areas, as revealed by the preceding account, *Neostapfia* occurs with only certain species of *Orcuttia* or stands alone. Likewise, only rarely are two species of *Orcuttia* associated, but if so, one of them is represented by only a few scattered individuals. All, however, demand the relatively large vernal pool beds for successful perpetuation.

2. It is suggested that their varying abundance from year to year is dependent upon the amount of rainfall and upon a long period of seed viability.

3. Morphological developments are a natural consequence of the environment with specializations directed towards viscidity, aroma, pubescence, and non-shattering inflorescences. Both genera are closely related, undoubtedly forming a natural grouping among the grasses, though their relationship to others is rather obscure.

4. A new species of *Orcuttia* from Solano County is described and illustrated.

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Bibliography

1. Carpenter, E. J. and S. W. Crosby. 1930. Soil Survey of the Suisun area. U. S. Dept. Agric. Bur. Chem. & Soils. Series 1930, Number 18: p. 33.
2. Hitchcock, A. S. and Agnes Chase. 1950. Manual of the grasses of the United States. 2nd Edition. USDA Misc. Publ. 100.
3. Hoover, Robert F. 1941. The genus Orcuttia. Bull. Torrey Club 68 (3):149–156.