

# ANATOMICAL FEATURES OF THE SUNFLOWER FLORET

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## INTRODUCTION

The anatomical features of sunflower *Helianthus annuus* var. *macrocarpus* (D.C.) Ckll. florets are being studied through cooperative research involving the USDA North Central States Bee Research Lab, Madison, WI and the USDA Oilseed Research Lab, North Dakota State University, Fargo, ND. The purpose of these studies is to identify and evaluate all of the structures of the sunflower inflorescence that influence honey bee (*Apis mellifera* L.) visitation. Specific attention is directed toward hybrid seed parents.

The sunflower inflorescence has two types of flowers on a single head or capitulum. Typically, the outer rim is defined by pistillate, sterile ray florets (Heiser, 1976; Hurd et al., 1980). Each is composed of five united petals that range in color from cream or yellow through yellow-orange to almost red (Knowles, 1978). The remainder of the capitulum is filled with hermaphroditic, protandrous disc florets (McGregor, 1976; Frankel et al., 1971; Knowles, 1978). The corolla tube of each floret is comprised of five fused petals which open distally to accommodate the emerging anther tube. Five fused anthers are attached to the base of the swollen corolla by flattened filaments.

Plant breeders are continually selecting desirable seed parent lines to improve heritable traits such as yield, quality or disease and insect resistance. F<sub>1</sub> hybrids which are produced by plant breeders utilize cytoplasmic male sterility (CMS). Occasionally, the backcrossing and selection process or inducement of CMS alters floral color and/or anatomy (Fink,

1978). Such flower abnormalities have already been noted in some seed parent lines or hybrids of alfalfa, crucifers, carrot and sunflower (Davis, 1983; Erickson et al., 1982, 1979 a, b; Erickson, 1983). These abnormalities probably contribute to observe non-random or restricted honey bee foraging among seed parents and reduced seed yield. Ironically, commercial breeders must rely on insect pollinators, particularly honey bees for pollen transfer from fertility restoring (RHA) to CMS lines.

We have been evaluating floral development among sunflower breeding lines and F<sub>1</sub> hybrids for the past three years. This paper describes the typical sunflower floret by means of scanning electron micrographs (SEM) taken of florets from 40 lines, varieties and species. Important aspects of floral development are presented here as guidelines for plant breeders.

## MATERIALS AND METHODS\*

Tubers and seeds of wild species were supplied by Dr. Gerald Seiler, USDA Conservation and Production Research Lab, Bushland, TX. Seeds of hybrid parent lines, their F<sub>1</sub> progeny and commercial varieties were provided by Dr. Jerry Miler, USDA, Fargo, ND. All were grown and studied at Madison, WI during 1981-1983.

Ultraviolet photographs of blooming sunflower were taken with a Honeywell-Pentax Spotmatic F/8 single-lens reflex camera with an ultra Achromatz Takumar fluorite quartz lens (85 mm, F/4.5) and a 365 μm filter. A series of exposures of 1/2, 1, 2, 5 and 10 seconds gave good results.

A 7-mm cork borer was used to remove plug samples from flowering heads of over 80 sun-

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flower types. The plugs were fixed in 2.5% glutaraldehyde buffered with 0.1 M phosphate. After 8 hours, the plugs were rinsed 3 times in fresh buffer solution and stored in 70% alcohol at 10°C.

To prepare specimens for SEM viewing, florets with attached achenes were separated from the plugs, dehydrated through a series of 10 minutes immersions in 85, 95, and 100% alcohol and then were dried in a Denton Critical Point Dryer. Dried specimens were mounted on aluminum stubs with silver conducting paint and coated with gold-palladium in a Denton Vacuum Evaporator. Florets were viewed in a JEOL-JSM-U3 SEM and photographed with Polaroid 55 P/N film.

## RESULTS AND DISCUSSION

### RAY PETALS

Ultraviolet (UV) absorbing and reflecting patterns on sunflower heads are evident (Fig. 1). These UV patterns are variable among genotypes and such differences may significantly influence pollinator foraging activities.

The upper surface of the ray petal is covered with densely packed specialized papillate epidermal cells (Brehm and Krell, 1975; Scogin, 1978) and trichomes (Fig. 2 a). The underside has nonpapillate cells and fewer trichomes. Surface textural differences between the UV-absorptive (dark basal region) and the UV-reflective (light distal region) areas were noted. Papillae on the UV-absorptive area of the petal were striated, conical structures (Fig 2 b) while those near the tip were globular (Fig. 2 c). It has been suggested (Buchman and Brehm, pers. comm.) that the conical papillae not only contain UV absorptive pigments but that they may be instrumental in directing light rays at the petal surface. We observed that variance in UV patterns and the structure of papillae was greater between species than among cultivars within a species.

### ANTHERS AND STIGMA

The tops of the anthers (Fig. 3) are usually covered with glandular and non-glandular trichomes (Fig. 4 a, b). Apparently, their number varies (Fig. 4 c, d) among genotypes (Kreitner et al., 1980). These trichomes may dehisce, be dislodged or be collected by foraging insects (Fig. 4 c) but their function is still not clearly understood (Erickson, 1983). It has been suggested that they may contain chemical agents that act as insect "repellents" or "attractants" (Kreitner et al., 1980; Rogers, pers. comm.).

Within the anther tube is the style, which elongates during the pistillate stage (Figs. 3 and 5) and forms a bi-lobed stigma (Erickson, 1983). As the stigma lengthens during floret maturation, it pushes out beyond the anther tube. Stiff hairs cover the outer, non-receptive surface of the stigma (Fig. 3): the length and density of these hairs vary between lines. Ultimately, the distal end of the mature bi-lobed stigma detaches medially and the tips curl outward, exposing their receptive inner surfaces (Fig. 6), which are covered with short, dense papillae (Putt, 1940; McGregor, 1976). If stigma prolongation is sufficient, some receptive surfaces may contact anthers of adjacent staminate flowers and self-pollinate. In some CMS lines stigma prolongation is reduced or excessive, thus reducing the pollination efficiency.

### THE NECTARY

Previous literature has misplaced the sunflower nectary (McGregor, 1976; Beard, 1981; Erickson, 1983). However, Tacina (1974, 1979) clearly located and photographed the nectary at the base of the style where it fits into the corolla "collar" (Fig. 3). Size, shape and frequency of nectary stomates have been documented (Sammataro et al., 1983, 1984) and significant variance between seed parent lines has been noted. Such differences may be genetically determined and may well contribute to marked variations in the quality and quantity of nectar and floral aroma. Our data indicate that strong correlations exist between honey bee foraging predilection and nectary size as well as stomate number and location (Fig. 7).

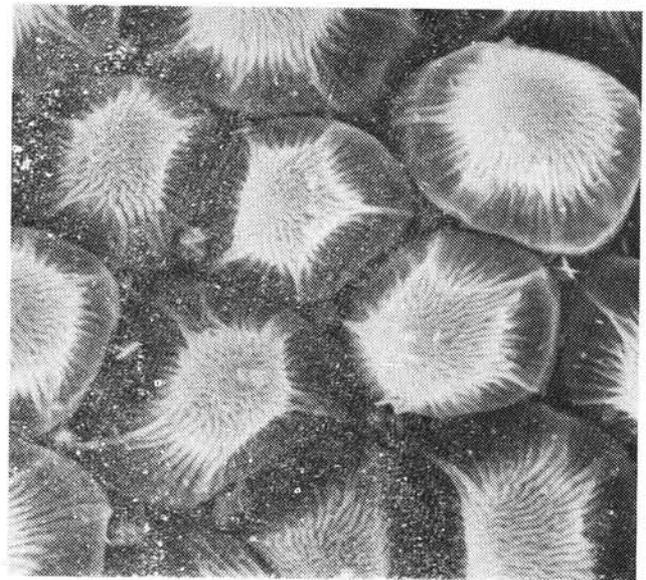
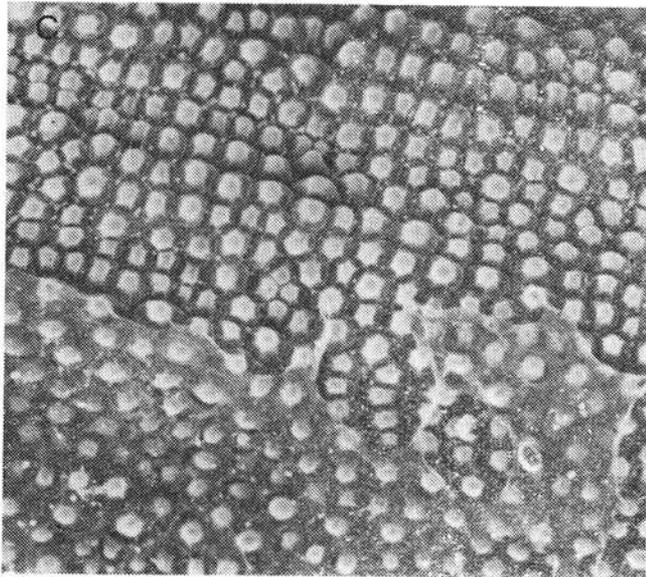
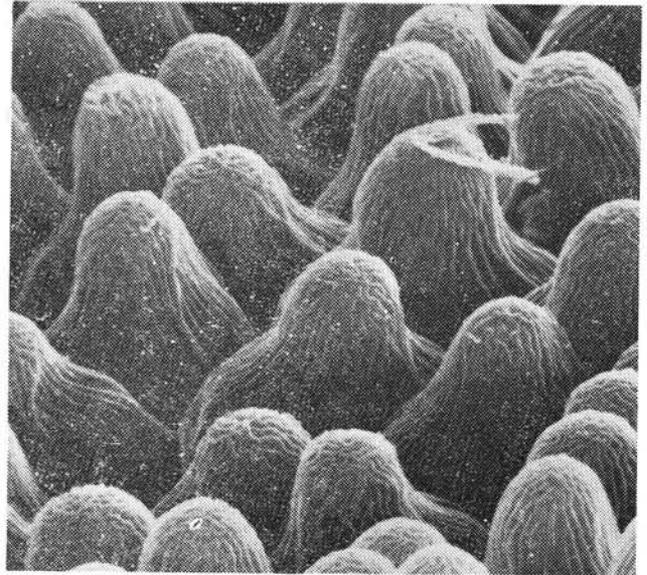
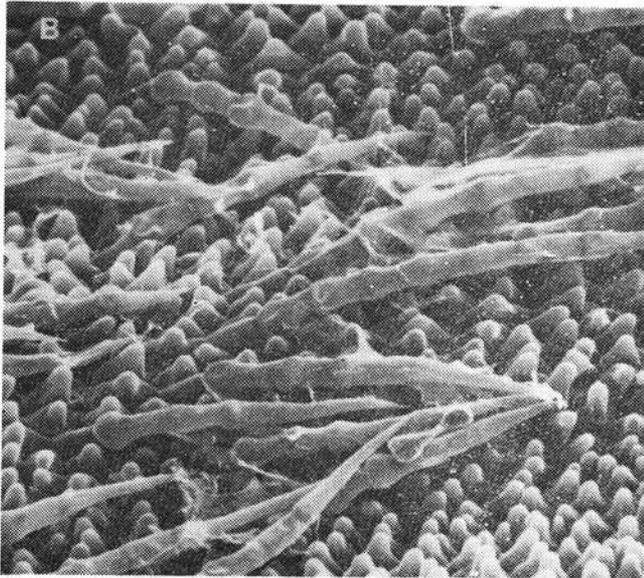
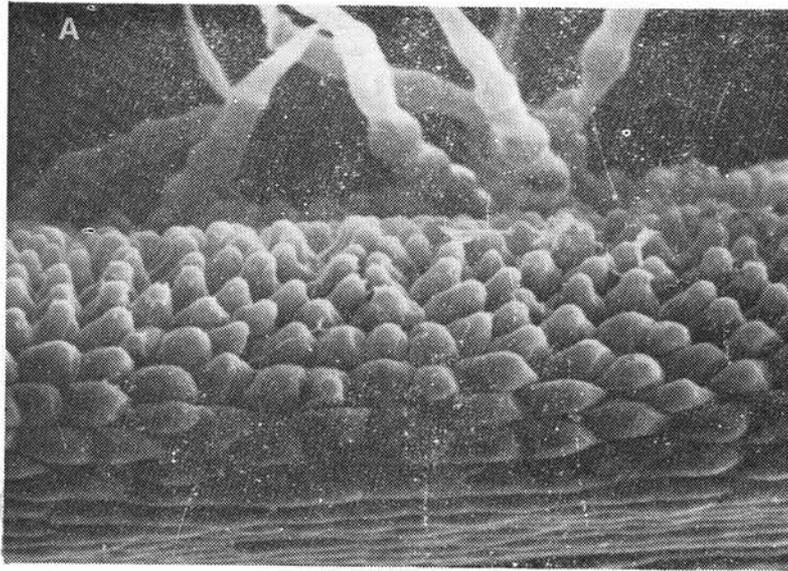
## CONCLUSIONS

We have described by photographs, typical development of sunflower florets as well as some heritable deviations from the norm. We are continuing to examine sunflower genotypes for other abnormalities. In addition, we are conducting nectar and aroma analyses and bioassays to determine the effect of observed floral abnormalities on pollinator foraging activities.

Breeding programs designed to produce self-pollinating hybrids may overlook structural anomalies inhibiting pollination by insects. However, breeding programs destined to produce lines that are both attractive and capable of being pollinated by insects must address these problems.



Fig. 1—Ultraviolet patterns of two sunflower heads  
a. *H. annuus* 768.  
b. HA 89



*Fig. 2 — Petal epidermal cells*  
*a.* Petal edge CMS 89 (X200) ; *b.* Basal petal end CMS 89 (X150 and 1000) ; *c.* Distal petal end CMS 89 (X150 and 1000).

REFERENCES

- Beard B. H., 1981, *The sunflower crop*, Sci. Am. 150—161.
- Brehm B. G. and D. Krell, 1975, *Flavonoid localization in epidermal papillae of flower petals: a specialized adaptation for ultraviolet absorption*, Sci. (190) : 1221—1223.
- Davis W. H., 1983, *Hybrid alfalfa*, In: *Handbook of Experimental Pollination Biology*, C.E. Jones and R. J. Little (eds.), Van Nostrand Reinhold, New York, pp. 501—504.
- Erickson Jr., E. H., 1983, *Hybrid sunflowers*, in: *Handbook of Experimental Pollination Biology*, C. E. Jones and R. J. Little (eds.), Van Nostrand Reinhold, New York, pp. 522—535.
- Erickson Jr., E. H., H. B. Garment and C. E. Peterson, 1982, *Structure of cytoplasmic male-sterile and fertile carrot flowers*, J. Am. Soc. Hort. Sci. 107 (4) : 698—706.
- Erickson Jr., E. H. and C. E. Peterson, 1979, *Asynchrony of floral events and other differences in pollinator foraging stimuli between fertile and male-sterile carrot inbreds*, J. Am. Soc. Hort. Sci. 104 (5) : 639—643.
- Erickson Jr., E. H., C. E. Peterson and P. Werner, 1979, *Honey bee foraging and resultant seed set among male-fertile and cytoplasmically male-sterile carrot inbreds and hybrid seed parents*, J. Am. Soc. Hort. Sci. 104 (5) : 635—638.

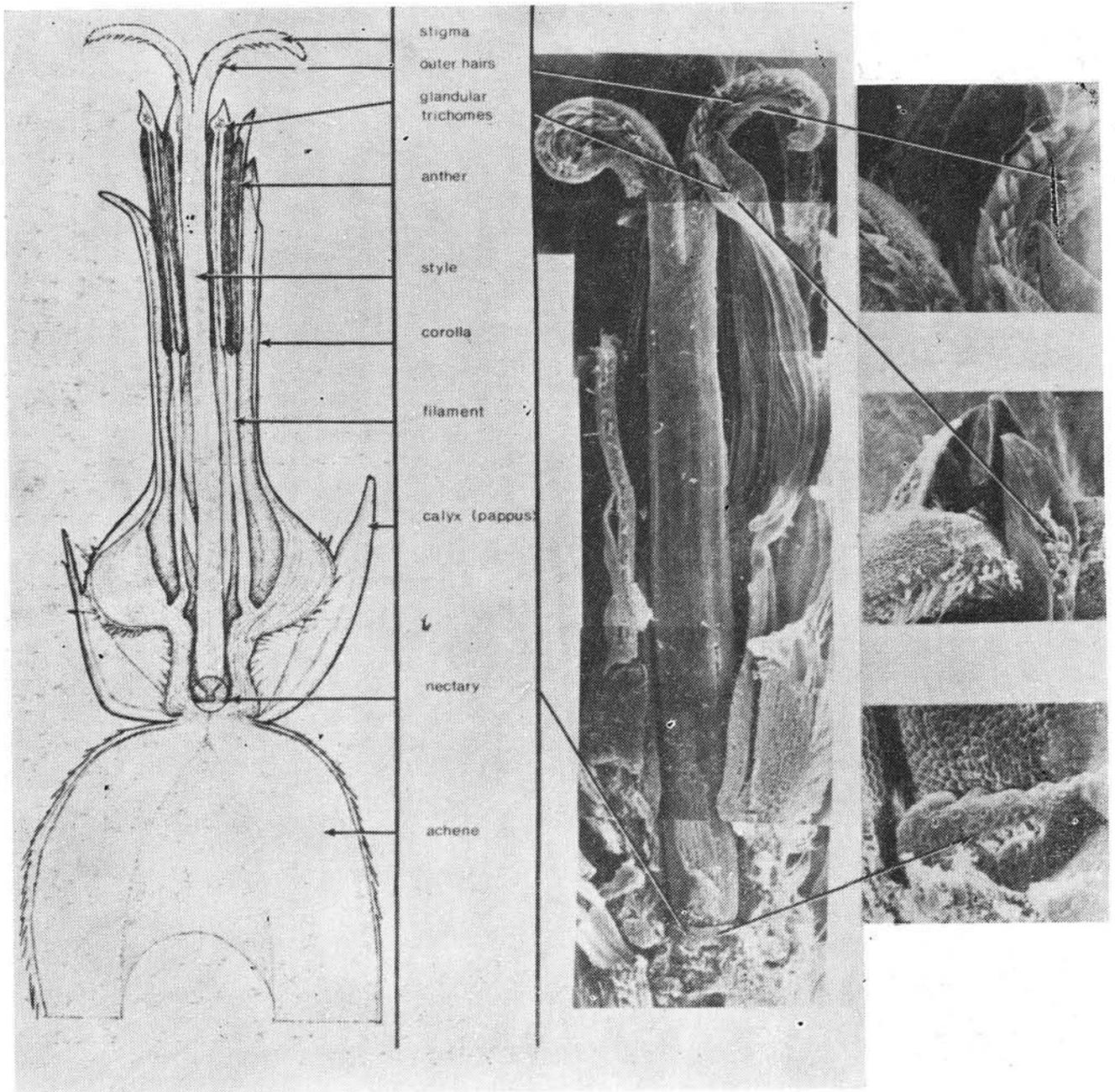


Fig. 3 — Diagram of sunflower floret  
Line drawing, E. Garvens ; Montage, M. Garment.

- Fick G. N., 1978, *Breeding and genetics*, In: *Sunflower Science and Technology*, Am. Soc. of Agron. and Crop Sci., Madison, WI pp. 279—338.
- Frankel R. and E. Galun, 1971, *Pollination Mechanisms, Reproduction and Plant Breeding*, Springer-Verlag, New York. 281 pp.
- Heiser C. B., 1976, *The Sunflower*, Univ. of Oklahoma Press, Norman, 198 pp.
- Hurd P. D., W. E. LaBerge and E. G. Linsley, 1980, *Principle Sunflower Bees of North America with Emphasis on the Southwestern United States* (Hymenoptera: Apoidea), Smithsonian Contrib. Zool. No. 310, 158 pp.
- Knowles P. E., 1978, *Morphology and anatomy*, In: *Sunflower Science and Technology*, Am. Soc. Agron. & Crop Sci. Soc. of Am., Madison, WI. pp. 55—85.
- Kreitner G. L. and J. Gershenzen, 1980, *Secretory Structures of Disk Florets as Possible Source of Chemical Resistance to Sunflower Moth Larvae*, Paper No. 639, Ent. Soc. Am., Atlanta, G.A.
- McGregor S. E., 1976, *Insect Pollination of Cultivated Crop Plants*, Agr. Handbook No. 496, USDA, 411 pp.
- Putt E. D., 1940, *Observations on the morphological characters and flowering processes in the sunflower (*Helianthus annuus* L.)*, Sci. Agr. 21 (4) : 167—179.
- Sammataro D., E. H. Erickson and M. B. Garment, 1983, *Intervarietal structural differences of sunflower (*Helianthus annuus*) florets and their importance to honey bee visitation*, Proc. Sunflower Research Workshop, Minot, ND.

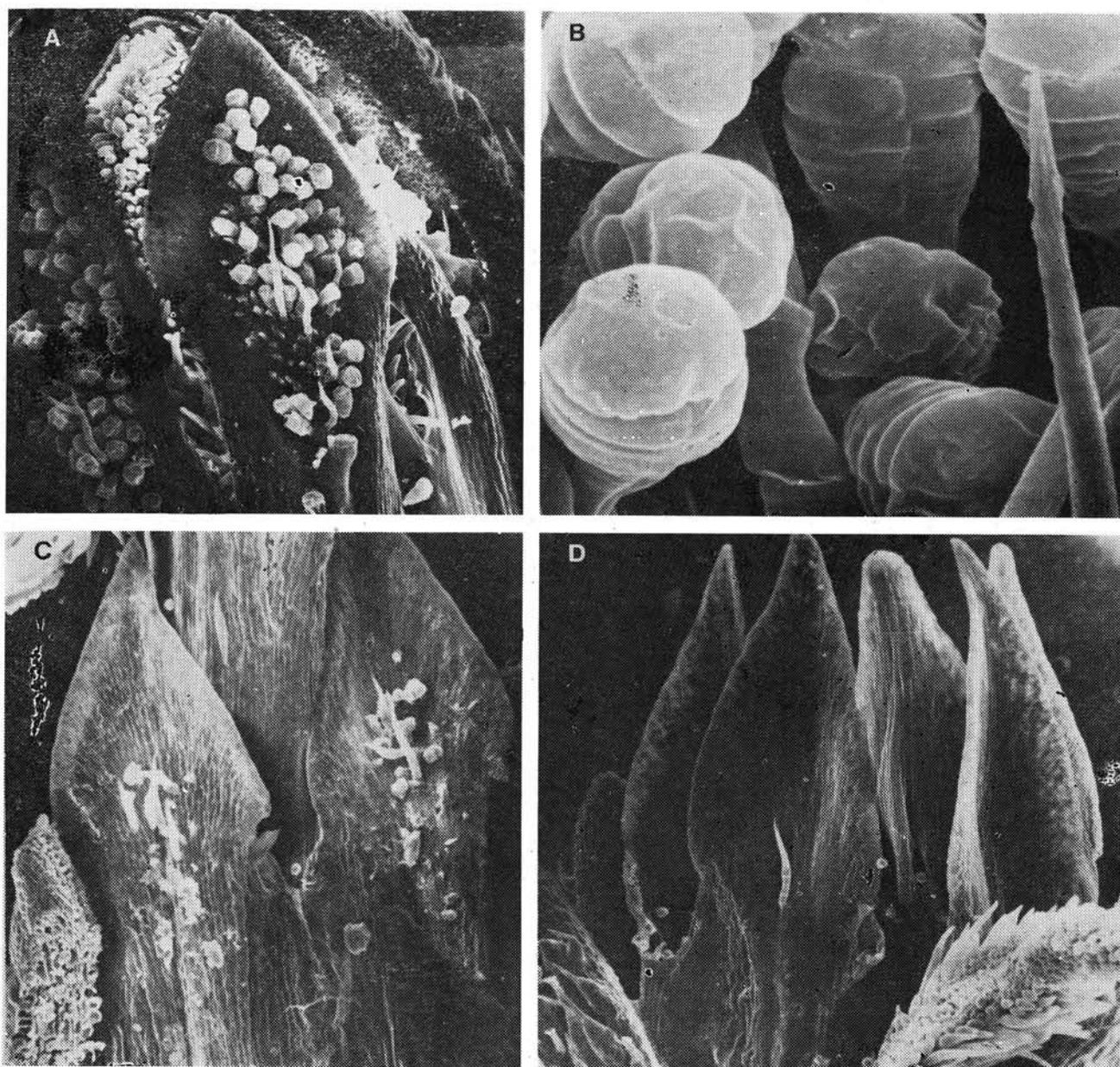


Fig. 4 — Glandular trichomes on anther tips  
 a. Bud floret of CMS 290 (X50) ; b. Close-up, glandular trichome HA 517 (X500) c. Anther tip, pistillate floret RHA 274 (X50) ; d. Anther tip, RHA 273 (X50).

Sammataro D., P. K. Flottum and E. H. Erickson, 1984, *Factors contributing to honey bee preferences in sunflower varieties*, Proc. Sunflower Research Workshop, Bismark, ND.

Scogin R., 1978, *Floral UV-absorption patterns and anthochlor pigments in asteraceae*, The Southwest Naturalist 23 (3) : 317—4.

Tacina F., 1974, *Observații morfo-anatomice comparative asupra glandelor nectarifere de la unele soiuri de floarea-soarelui*, In: *Studii și cercetări de Biologie* 26 (1) : 3—7, Bucharest.

Tacina F., 1979, *Corelația dintre ultrastructura celulelor nectarifere și secreția de nectar la floarea-soarelui*, Apicult. în România 54 (7) : 15—19.

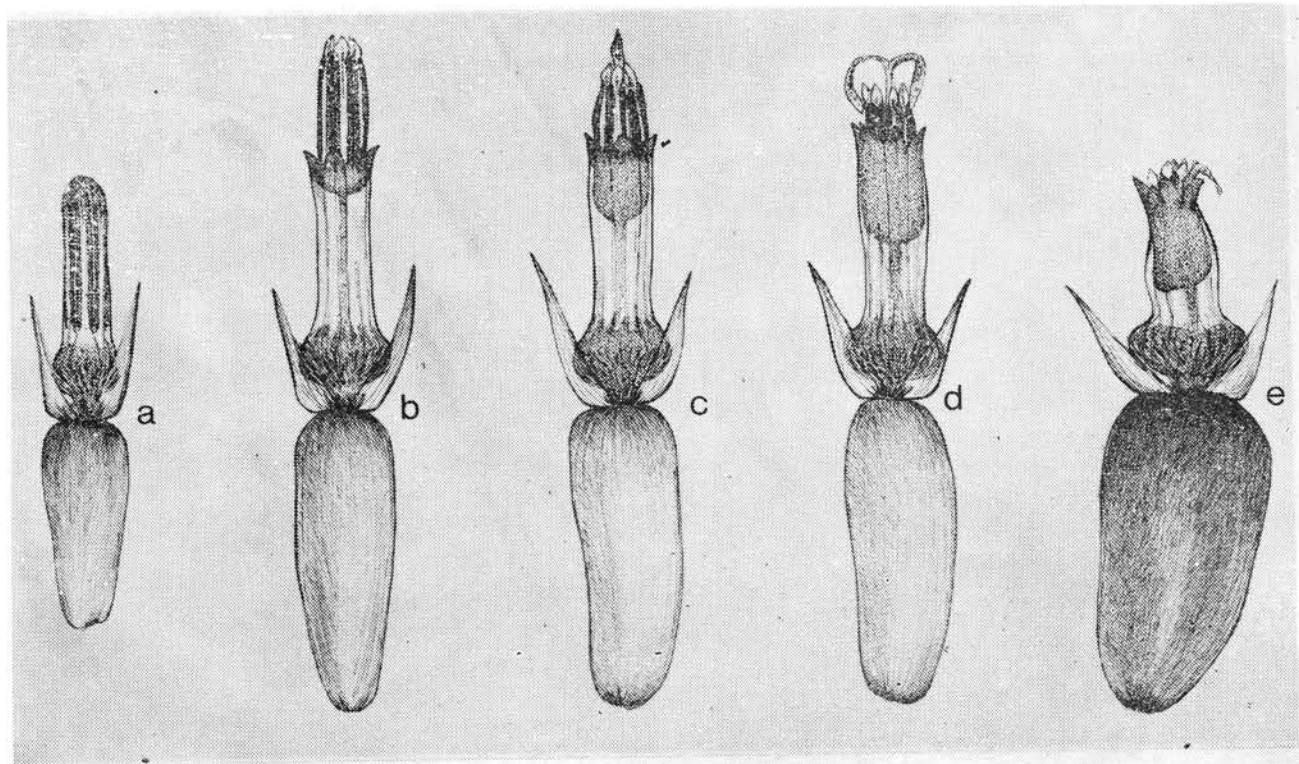


Fig. 5 — Stages of sunflower floret maturation (E. Garvens)  
a. unopened bud ; b. staminate ; c. transitional ; d. pistillate ; e. mature (wilted).

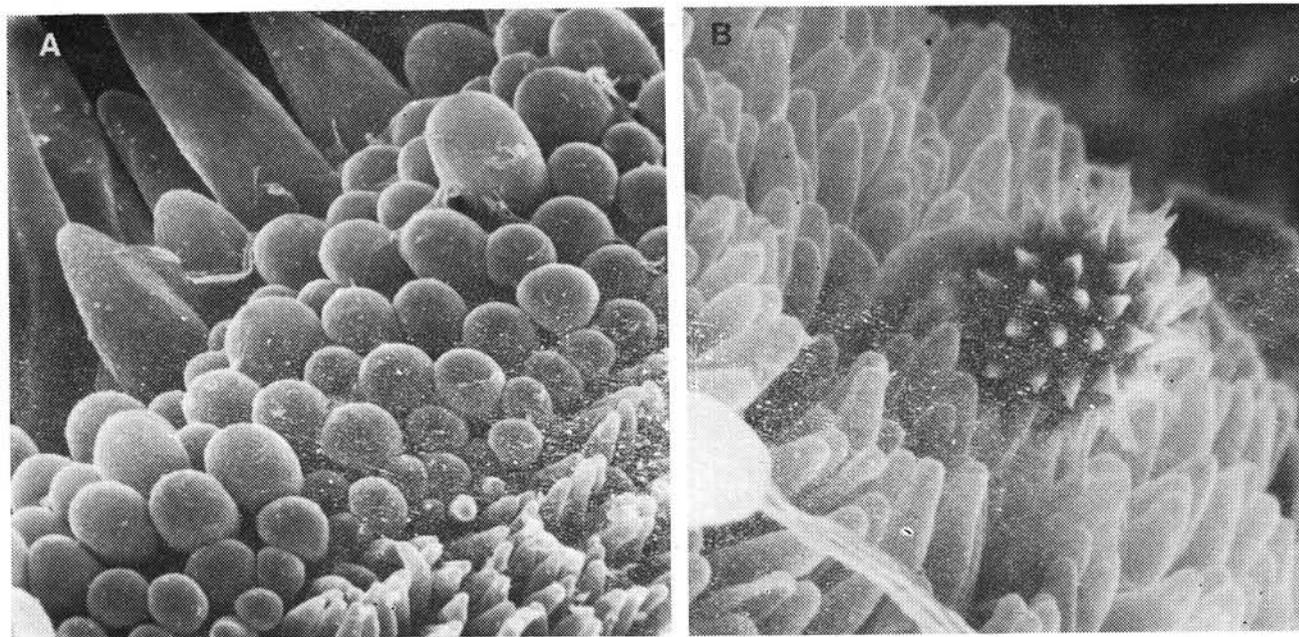


Fig. 6 — Stigma surface of sunflower floret  
a. Edge of stigma showing transition from outer, non-receptive hairs to inner receptive papillae of 894 (X500) ; b. Pollen tube growth on inner, receptive papillae of CMS 89 (X1000).

## LES CARACTÉRISTIQUES ANATOMIQUES DE LA FLEUR DE TOURNESOL

### Résumé

La fleur typique de tournesol est décrite à l'aide des photographies, résultant de l'étude au micrographe électronique à balayage, les fleurs étant prises de 40 lignées, variétés et espèces. Certains aspects du développement floral sont présentés, importants pour l'amélioration du tournesol. Quelques déviations héréditaires de la forme normale sont également décrites.

Les effets des anomalies florales sur l'activité des insectes pollinisateurs ont été déterminés, à l'aide des analyses et biotests de nectar et arôme.

Les programmes d'amélioration destinés à la production des hybrides autofertiles peuvent négliger les anomalies structurales inhibant la pollinisation par insectes. Cependant, les programmes d'amélioration désignés à produire des lignées présentant attraction et capacité de pollinisation par insectes doivent tenir compte de ces aspects.

## CARACTERÍSTICAS ANATÓMICAS DE LA FLOR DE GIRASOL

### Resumen

En el artículo se describe con ayuda de las fotos, la flor típica de girasol estudiada con la ayuda del micrografo electrónico, las flores siendo escogidas de 40 líneas, variedades y especies. Están presentados algunos aspectos del desarrollo floral que presenta importancia para la mejora del girasol. Se describen asimismo unas desviaciones ereditarias de las formas normales.

Con la ayuda de los análisis y los biotests de néctar y aroma se determinaron los efectos de las anomalías florales sobre la actividad de los insectos polinizadores.

Los programas de mejora destinados a la producción de híbridos autofértiles pueden descuidar las anomalías que inhiben la polenización por insectos. Sin embargo, los programas de mejora destinados a producir líneas que presentan atractividad y capacidad de polenización por insectos tienen que contar con estos aspectos.

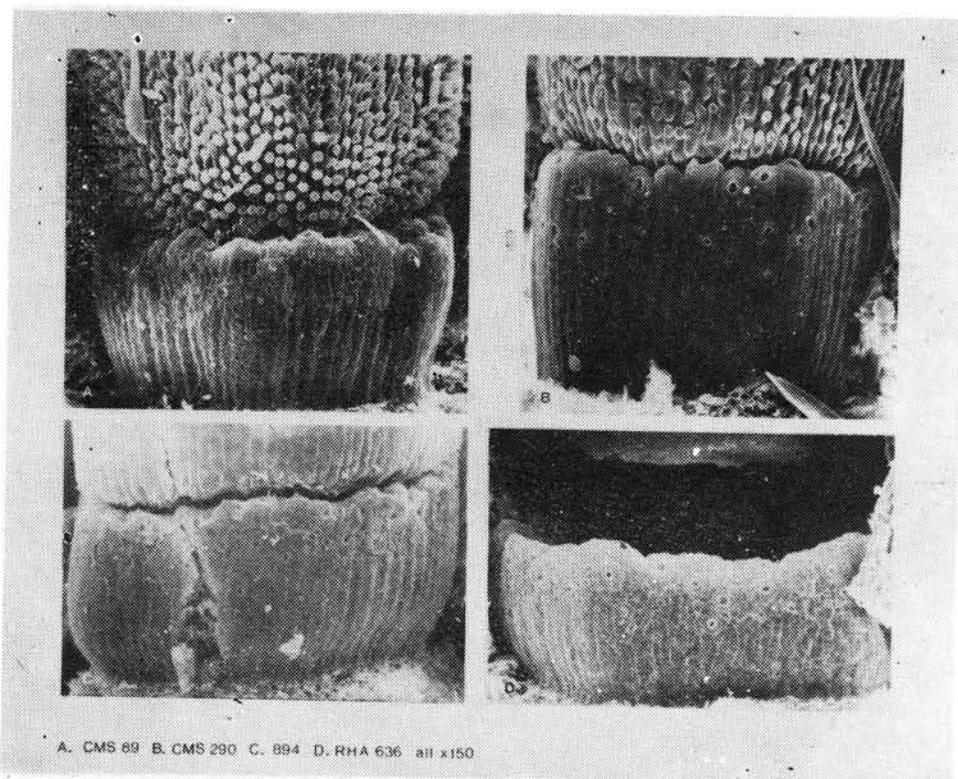


Fig. 7 — Nectaries of sunflower florets  
a. CMS 89 (X82) ; b. CMS 290 (X62) ; c. Hybrid 894 (X82) ; d. RHA 636 (X82).