"Blinding" of shoots and a leaf gall in Amsinckia intermedia induced by Anguina amsinckia (Steiner and Scott, 1934) (Nemata, Tylenchidae), with a note on the absence of a rachis in A. amsinckia

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Abstract: "Blinding" and a leaf gall induced on *Amsinckia intermedia* Fisch. and Mey. by *Anguina amsinckia* (Steiner and Scott) are described. *A. amsinckia* induced blinding by galling the terminal apical meristem of its host. The leaf gall was formed by a ventral curling of the distal edge of the leaf. The absence of a rachis in the ovary of *A. amsinckia* is noted. *Key Words: Anguina* morphology.

Anguina amsinckia (Steiner and Scott, 1934) parasitizes the common fiddleneck *Amsinckia intermedia* Fisch. and Mey., an annual weed of the central valley of California capable of inducing pathological disorders in livestock if ingested in sufficient quantities (2). Since *A. amsinckia* is a potential biological control agent of *A. intermedia,* knowledge of its biology and ecology is of economic as well as scientific importance.

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MATERIALS AND METHODS

A population of *A. intermedia* illustrat-

ing the nematosis was discovered in April 1979 along Eggert Road, about 6.4 km south of Davis, California. As in other cases of parasitized *A. intermedia* (3,5), the nematosis was very localized, affecting plants in an area only about 20 m long. At the time of the discovery, the majority of the plants were still in bloom, and the galls, some as large as 20 mm in diameter, had not yet begun to dry. Galled plants were collected and brought back to the laboratory for examination. Galls and specimens of *A. amsinckia* were fixed in 10% buffered neutral formalin, dehydrated in an ethanol series, and then infiltrated and embedded in glycol methacrylate (4). Trimmed mounted blocks were sectioned at 2 μm on an ultramicrotome, stained with Lee's methylene blue-basic fuchsin (1), and examined under the light microscope.

RESULTS

Galling of *Amsinckia* by *A. amsinckia* is usually limited to the fruit. In this collection, however, the terminal apical meristems were attacked and transformed into elongated galls covered with numerous fine hairs (Fig. 1-A). Small undeveloped leaves were present at times. Lateral branching is not uncommon in *Amsinckia,* and this "blinding" did not necessarily prevent seed production (Fig. 1-C).

A gall was discovered on the distal tip of a leaf obtained from a plant that possessed fruit galls (Fig. 1-D). The gall was about 4 × 2 mm and, like other galls, was covered with numerous fine hairs that gave it a silvery appearance. The gall was formed by a curling of the edge of the leaf ventrally, such that in cross-section (Fig. 1-B) a curl of about one and one-third revolutions was seen.

Fruit and leaf galls were similar in the hypertrophy and hyperplasia of the epidermal and mesophyll layers and of the vascular bundles (Fig. 1-E,G). A layer of dead, empty cells usually lined the inner cavity of the gall. The wall of the gall, in cross-section, could be divided into two halves. The exterior half, while exhibiting hypertrophy and hyperplasia, did not usually reveal any apparent change in intracellular organization, i.e., the tissues stained similarly to normal tissues. In contrast, tissues of the interior half of the gall wall possessed cells with prominent nuclei and cytoplasm, centrally located, that generally stained darkly (Fig. 1-H).

Histological sections of *A. amsinckia* from galls were examined for a rachis in the gonad. None were found in cross-sections of the ovary (Fig. 1-F). Careful examination of sections suggestive of the rachis of *A. tritici* as drawn by Thorne (6) revealed the "rachis" to be a maturing oocyte surrounded by what appears to be oviductal cells (Fig. 1-F).

DISCUSSION

Prior to this investigation, it was believed that *A. amsinckia* attacked and formed galls only in the fruits of its host (3). Godfrey (3) found no evidence of nemas in leaves, bracts, or stem tissues, and neither he nor Steiner and Scott (5) reported galls of tissues other than those of fruits.

Godfrey (3) showed that *A. amsinckia* induced fruit galls by migrating between the sepals and petals of the flower bud, stimulating growth of the surrounding floral organs so that gall tissues arch over the feeding nemas, forming a cavity. Galls in the terminal apical meristem and leaf tissue are probably induced in a similar way. The fact that galling was induced in terminal apical meristematic tissue and a leaf by *A. amsinckia* demonstrates that floral tissues are not essential. Actively growing tissues are probably essential. The more common occurrence of galls in fruit and terminal apical meristems may result from the infective nematodes' sensitivity to desiccation. The relative humidity is probably higher between the leaves of a bud than on the exposed surface of a leaf. Possibly leaf galls are formed only under very moist conditions.

Sections failed to substantiate Thorne's (6) belief that a rachis exists in the ovary of *A. amsinckia.* Cross-sections of oocytes in the oviduct of *A. amsinckia* are very similar to the "rachis" of *A. tritici,* which we believe is really an oocyte surrounded by oviductal epithelium. The developing oocytes in the distal end of the ovary are not in single file; there may be six or more in a cross-section. There is, however, no evidence that they are arranged about a central core

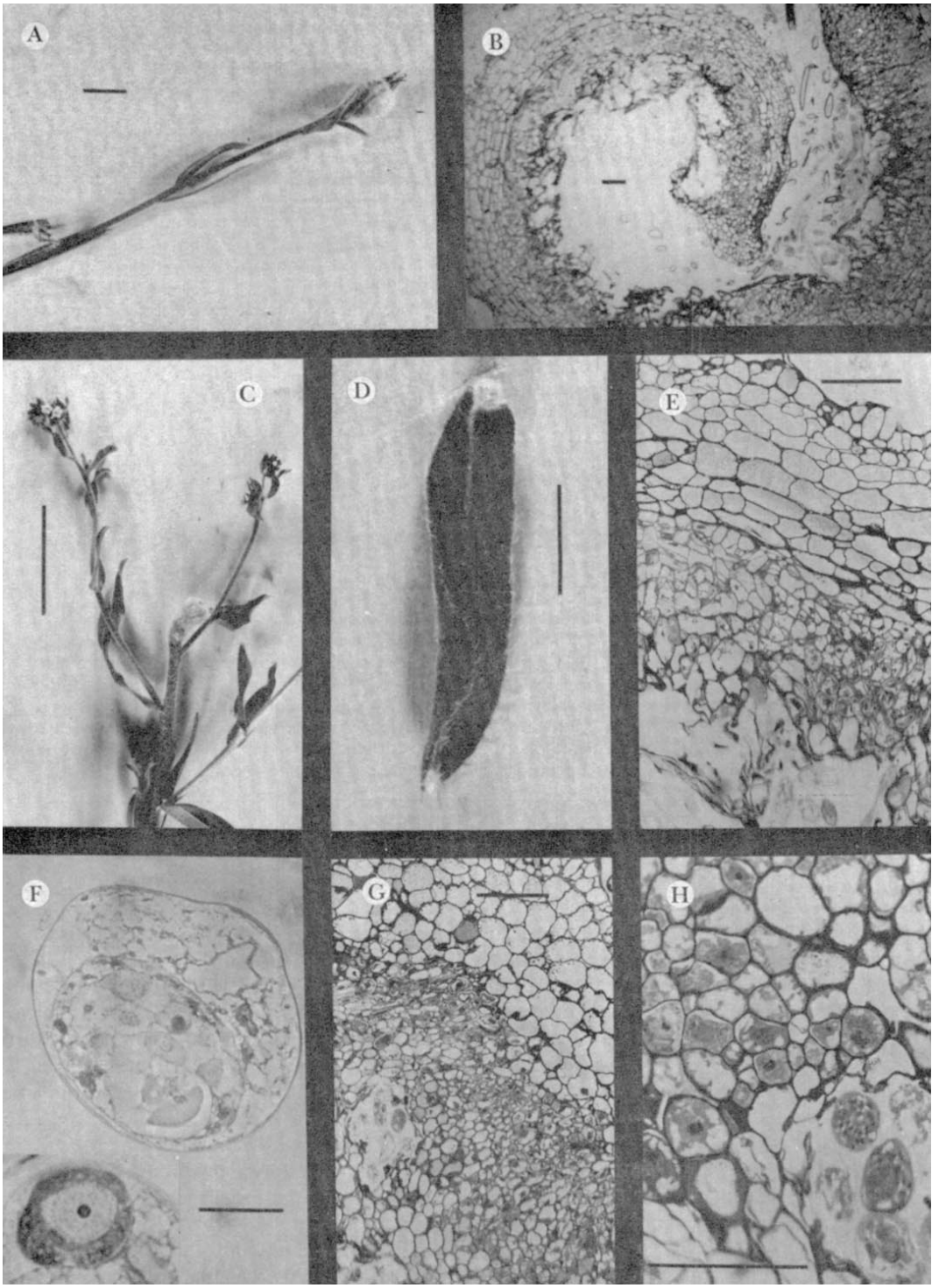

Fig. 1. A) "Blind" plant of *Amsinckia intermedia* (line length = 15 mm). B) Cross-section of the leaf gall showing rolling of the leaf (line length = 100 μm). C) "Blind" plant that has developed lateral shoots and flowers (line length = 50 mm). D) Leaf gall as seen on leaf tip (line length = 10 mm). E) Cross-section of leaf gall showing dead broken cells, interiorly, dark-staining cells, centrally, and exterior cells similar in staining to normal cells (line length = 100 μm). F) Cross-section of *A. amsinckiae* female body and oviduct showing oocytes arranged randomly with no rachis. (Inset) germinal region of ovary showing oocyte surrounded by cells of oviduct (line length = 30 μm). G) Longitudinal section of fruit gall showing the same layers as in Fig. 1-E (line length = 100 μm). H) Dark-staining cells with central nuclei adjacent to feeding area. Note cell on right with amoeboid nucleus (line length = 100 μm).

(=rachis). The presence of a rachis is well established in ascarids, oxyurids, strongylids, and spirurids. This histological study on *A. amsinckia* indicates that the so-called "rachis" is a morphological misinterpretation and should not be used as a taxonomic character.

LITERATURE CITED

1. Bennett, H. S., A. D. Wyrick, S. W. Lee, and J. H. McNeil, Jr. 1976. Science and art in preparing tissues embedded in plastic for light microscopy, with special reference to glycol methacrylate, glass knives and simple stains. Stain Technol. 51:71-97.

2. Fischer, B. B., A. H. Lange, J. McCaskill, and B. Crampton. 1974. Index to the growers weed identification handbook. Identification sheet WI-6. Agricultural Extension, University of California.

3. Godfrey, G. H. 1940. Ecological specialization in the stem- and bulb-infesting nematode Ditylenchus dipsaci var. amsinckiae. Phytopathology 30: 41-53.

4. Nagamine, C., A. W. Knight, A. Maggenti, and G. Paxman. Effects of androgenic gland ablation on male primary and secondary sexual characteristics in the Malaysian prawn, Macrobrachium rosenbergii (de Man) (Decapoda, Palaemonidae), with first evidence of induced feminization in a nonhermaphroditic decapod. (Submitted for publication.)

5. Steiner, G. and C. E. Scott. 1934. A nematosis of Amsinckia caused by a new variety of Anguillulina dipsaci. J. Agr. Res. 49:1087-1092.

6. Thorne, G. 1961. Principles of Nematology. McGraw-Hill Book Co., New York. 553 pp.