The Distinct Morphology and Germination of the Grains of Two Species of Wild Rice (*Zizania*, Poaceae)

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Grain morphology alone can be used to distinguish the two species of annual wild rice, *Zizania aquatica* and *Z. palustris*. Their sequence of development during germination differs from that of most other grasses.

Key Words: *Zizania*, Poaceae, wild rice, germination, epiblast.

Current research has indicated that it is possible, with only a single grain, to identify the annual taxa of wild rice to species level. This is particularly relevant early in the growing season when it is easy to uproot a developing seedling with the grain attached, and identify it as either *Zizania aquatica* L. or *Z. palustris* L. — distinct from young *Vallisneria*, or *Sparganium* species that look similar.

Grain morphology

Fassett (1924) described morphological characters of the grains of annual wild rice to distinguish between the varieties of *Zizania aquatica* that he recognized (separating varieties *aquatica* L. and *brevis* Fassett, from *angustifolia* Hitchcock and *interior* Fassett). Dore (1969) photographed groups of ripe grains of *Z. aquatica* and *Z. palustris*, the two species that he recognized, but used other morphological characters to distinguish taxa. Dore and McNeill (1980) presented characteristics of the grains and spikelets as a major way to distinguish two species. There is an unfortunate mistake in the keys presented in Dore and McNeill (1980) in that the word "staminate" appears in place of the word "sterile". The distinction intended by W. G. Dore (personal communication) is that the spikelet bracts of *Z. aquatica* are thin-textured and when a grain fails to enlarge within them, they remain crimped and less than 1.5 mm wide (Figure 1b). The surface of the flowering bracts have sparse, minute, siliceous trichomes all over (Figures 1a; 2, left) and the ripe grains tend to cling to your hands and clothing. The bracts of *Z. palustris* are quite rigid, develop to their full size at flowering time and remain almost the same width, 1.5–2.0 mm, whether the caryopsis develops or not (Figure 1d). Trichomes on the flowering bracts of *Z. palustris* are limited to the apex and along the veins, usually more towards the apex (Figures 1c; 2, right).

W. G. Dore (personal communication) has stressed the size and position of trichomes on the larger floral bract, the lemma, as a useful taxonomic character. My observation is that the presence or absence of such trichomes on the mid-region of the palea is also characteristic and consistent in the two species. This feature is illustrated in Figure 2, which shows that the exposed surface of the palea of *Z. aquatica* (left) is sparsely covered with tiny siliceous trichomes, whereas the same surface of the palea of *Z. palustris* (right) is smooth.

Grain structure and germination.

In all annual taxa of wild rice, the grain is enclosed in the remains of the flowering spikelet with its two interlocking bracts. The grain consists of an elongated caryopsis (the ripened ovary characteristic of the grass family), and contains the seed with its embryonic plant as well as food reserves. The detailed structure of the caryopsis was described by Weir and Dale (1960). It is unusual in having a cotyledon that extends the entire length of the grain and an epiblast that is long and prominent (LaRue and Avery 1938).

Some features of the germination pattern of wild rice are here documented as unusual among grasses. These are (1) that the shoot appears before the root, and (2) that the epiblast emerges from the caryopsis. In all taxa of *Z. aquatica* and *Z. palustris*, the first evidence of sprouting is the appearance of a white slit in the lemma of an otherwise dark grain. Embryo enlargement splits the relatively thin, brown caryopsis wall and then the lemma along tissue adjacent to the midvein, exposing white epiblast tissue. In explaining the structure of a caryopsis, the epiblast has been variously interpreted, often as a cotyledon, or as part of one (Cutter 1971). In wild rice, the epiblast is one quarter to one third as long as the whole caryopsis and up to 1 mm wide at the base. It emerges first (Figure 3a) followed by the coleoptile (Figure 3b). At this stage, the epiblast appears swollen and fleshy; it may function to absorb water and convey it to the developing embryo. At the very least, the way in which

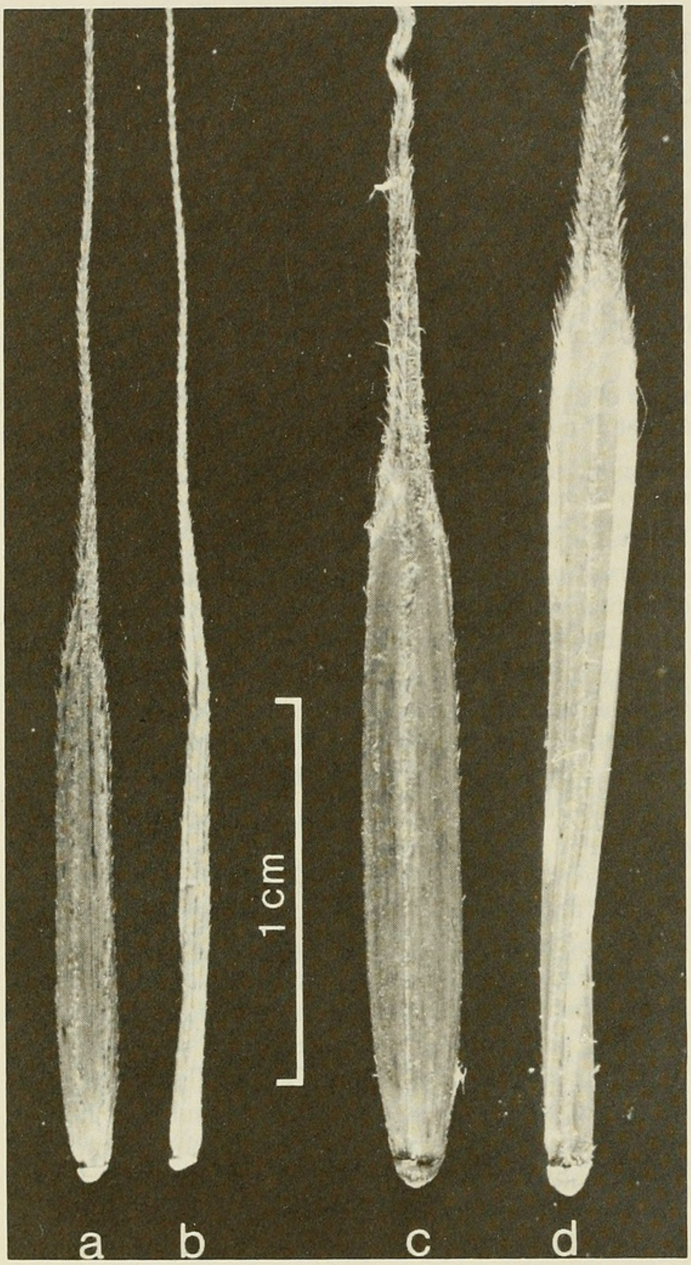

FIGURE 1. A comparison of the lemma surfaces of *Z. aquatica* (a,b) and *Z. palustris* (c,d); fertilized spikelets (a and c), sterile spikelets (b and d).

the epiblast curves away from the grain allows water easy access to soak into the inner portions of the caryopsis.

Figure 3b shows the epiblast that in Figure 3a was lying on the elongating coleoptile. Only after the coleoptile is well established (Figure 3c) does the primary root begin to emerge by penetrating the lemma towards the base of the grain where it was attached to the parent plant. Figure 3c shows the emerging root, the epiblast, and the elongating first internode with a bulge that is the first stem node, towards the top of the picture. Above the first node is the sheath of the first leaf.

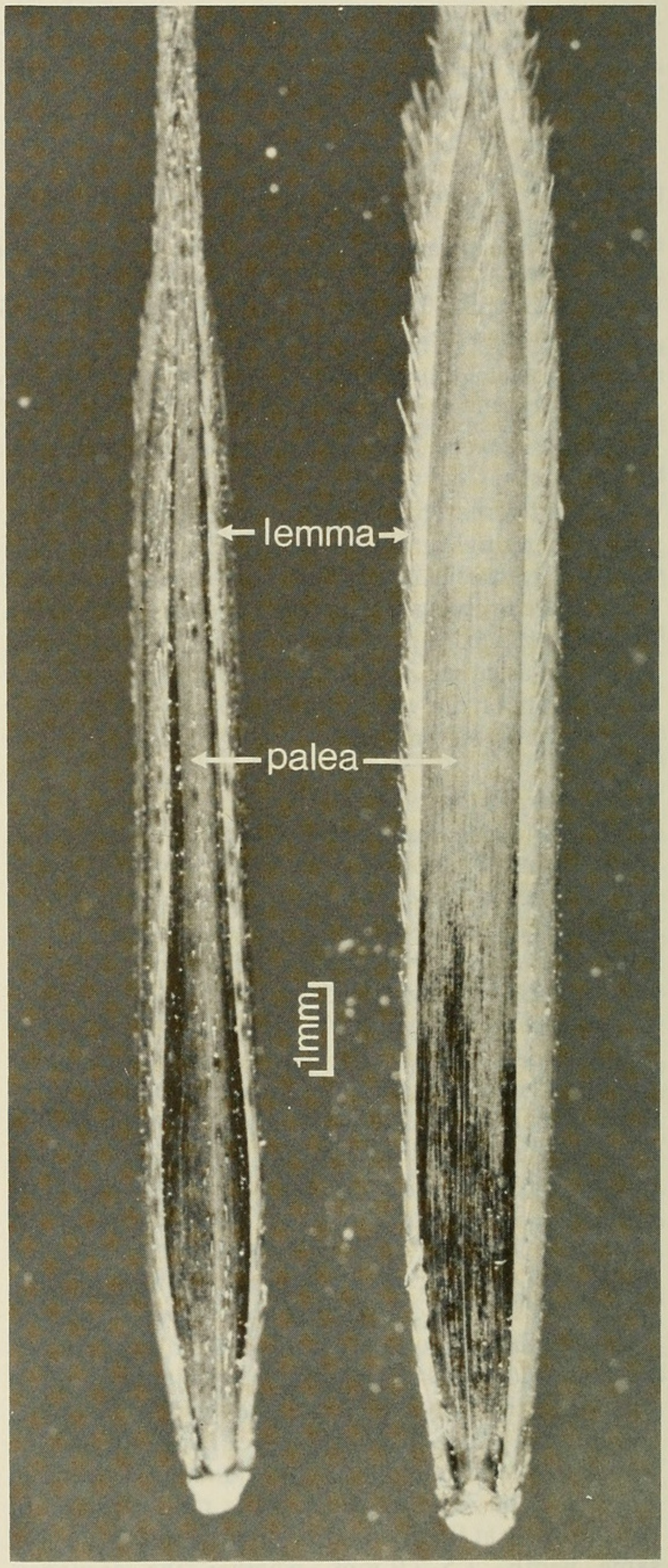

FIGURE 2. A comparison of the exposed palea surfaces of (left) *Z. aquatica* with minute trichomes and (right) *Z. palustris* with a glabrous surface.

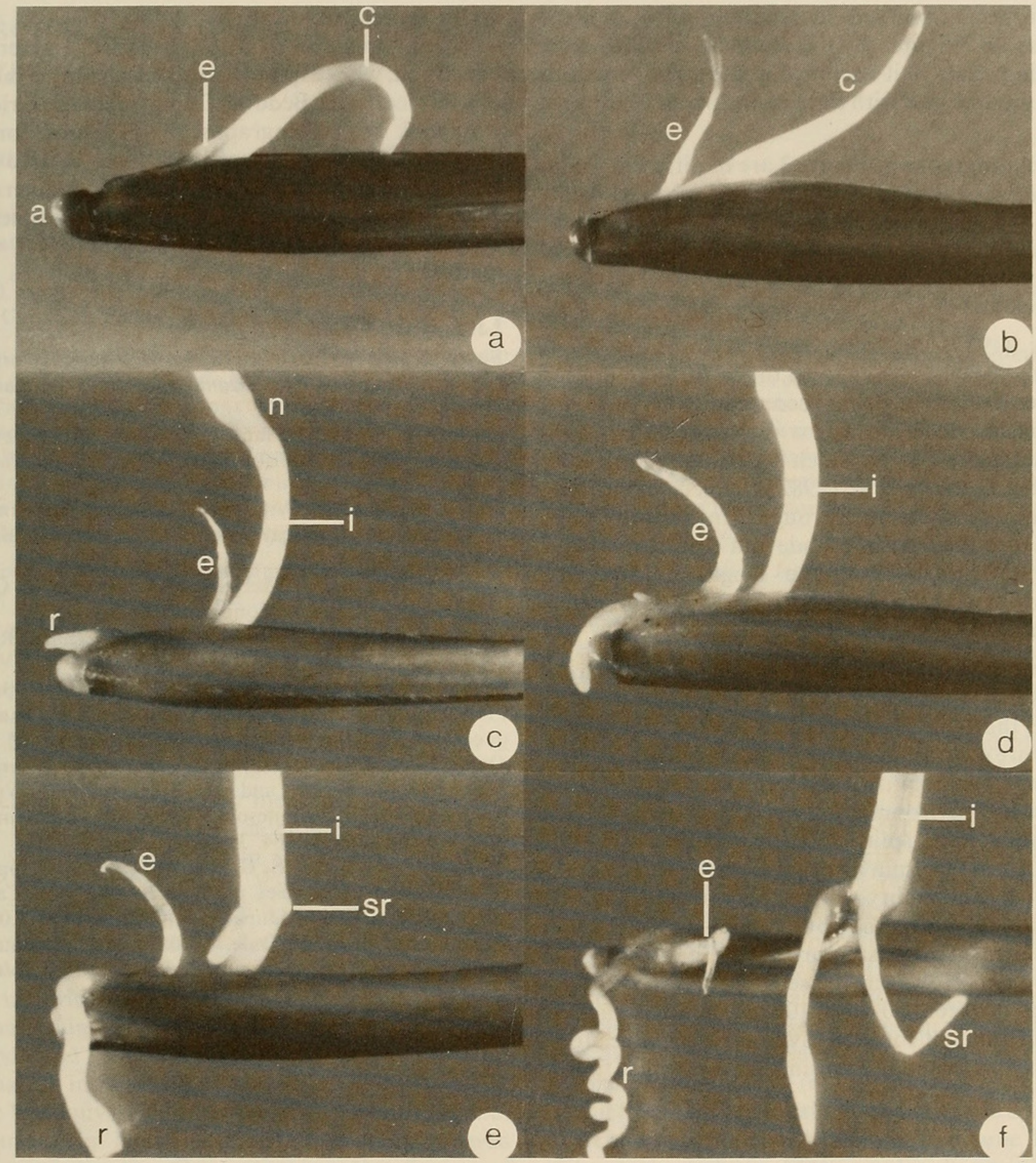

FIGURE 3. Stages in the germination of *Z. palustris* caryopses: a = point of attachment of grain, c = cotyledon, e = epiblast, i = internode, n = node, r = root, sr = secondary root.
(a) The caryopsis wall and lemma have split; the cotyledon is curled as it emerges from the grain; the epiblast is lying on the coleoptile. (b) The coleoptile has emerged from the grain and the epiblast has separated from the cotyledon. (c) The shoot below the cotyledon has elongated, exposing the first node and internode. The shoot is 2-3 cm long when the first root emerges and (d) curls towards the substrate. (e) Soon after the primary root is established, secondary roots begin to develop. (f) As secondary roots develop the epiblast shrinks and withers.

The grains photographed were germinated in about 7 mm of tap water in a petri dish; the first internode that developed was less than 5 mm long. The portion of the lemma between the epiblast and the first root remained intact (Figure 3d). At an early stage, secondary roots began to develop from the first internode (Figure 3e). These eventually replaced the primary root, as is characteristic of many grasses. The curling of the primary root (Figure 3f) is attributed to the germination of the grains in a petri dish, since it has not been observed in seedlings from natural habitats. In Figure 3f the epiblast is shrunken, suggesting that, if it assumed some root functions earlier, these ceased with the establishment of the root system.

The photographs in Figure 3 are of different grains of *Z. palustris*, but all are magnified approximately 3.5X. The same germination pattern was observed for all annual wild rice taxa, in an isoenzyme experiment that involved growing more than 3000 seedlings (Warwick and Aiken 1985).

Bayly (1983) regarded the caryopsis, with its associated bracts, as a support organ for germinating wild rice. In the figure that accompanies her note, the seedling illustrated has a first internode (mesocotyl) more than 60 mm long, which is unusually long, even for wild rice. Oelke et al. (1982) claimed that a "wild rice seedling can emerge through 3 inches of flooded soil because the first internode can elongate up to 2 inches" (50 mm). Thus, the length of the first internode in wild rice may vary from a few millimeters (Figures 3e,f) to 60 mm.

In almost all seed plants, including grasses, the root emerges from the seed first. This has been presumed to indicate that the primary needs of the developing embryo are support from the root acting as an anchor, and water to mobilize food reserves. In wild rice, water in the environment is not a problem once the grain walls have split, and the emergence of the epiblast from the grain also assists in the early uptake of water by the embryo. The grain structure (Bayly 1983) along with the buoyancy of the water environment provide support for the early stages of development. However, the seedling shoot may have to grow between 50 and 100 cm before reaching sufficient sunlight for photosynthesis to replace food reserves, and this may explain why it emerges first.

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