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Authors
ARDITTI, J
HARRISON, CR

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POSTPOLLINATION PHENOMENA IN ORCHID FLOWERS. VIII.
WATER AND DRY WEIGHT RELATIONS

JOSEPH ARDITTI AND CHARLES R. HARRISON
Department of Developmental and Cell Biology, University of California, Irvine, California 92717; and
Department of Biology, Saddleback College, Mission Viejo, California 92675

Pollination causes increases in FW and DW of Cymbidium ovaries and gynostemia. It also initiates
FW losses in perianth segments. Auxin (NAA) applications to the stigma have the same effects except
that FW of ovaries decreases. All segments of unpollinated flowers increased in DW, whereas FW variations
were minimal. These weight changes reflect the aging and subsequent death and/or redifferentiation and
further development of pollinated and/or unpollinated orchid flowers.

Introduction

Wilting of sepals, petals, and labella (lips); swelling of gynostemia (columns) which subsequently
become green; and increases in the diameter of ovaries are among the most easily observable post-
pollination phenomena in orchid flowers. One intuitive explanation (Hubert and Maton 1939; Hsiang
1951a) for these phenomena is water gains in organs which swell and water losses in those that wilt.
Increases and decreases in dry-matter content of floral segments may also occur, thereby affecting
FW and DW. The available evidence indicates that, after pollination, substances are mobilized from the
perianth into gynostemia and ovaries (Fitting 1909a, 1909b, 1910; Schumacher 1931; Seshagiri

Should the movement of water and dry matter be simultaneous, FW changes would reflect both, whereas
dW variations can indicate only the latter. The relationship between water and dry matter determines
the hydration of tissues and is expressed as HV (Baldovinos 1953; Hinnawi 1973), which is a parameter
that can provide information on whether the gains or losses of dry matter and water differ in magnitude.

Material and methods

Flowers.—Racemes of Cymbidium 'Jungfrau'
(lathehouse-grown plants, U.C.I. orchid collection), harvested after all but the two or three apical buds
had opened, were placed in water for 12-16 h. Flowers were cut at the pedicel base just before the
start of the experiments. Ovaries and pedicels were decontaminated by a 5-min immersion in saturated
calcium hypochlorite (ARDITTI and KNAUFT 1969).

Culture medium and conditions.—Modified
Knudson C medium (ITO 1961) was dispensed into
rubber-capped tubes of the kind used to ship orchid
flowers (Acme Glass and Vial Co., Los Angeles), sterilized by autoclaving, and allowed to stand on a
bench top for 48 h to allow for dispersion of any ethylene which might be produced by the caps as a
result of the sterilization. Pedicels were inserted through holes in the rubber caps (ARDITTI, JEFFREY,
and FLICK 1971b), and the tubes were placed in small cans. All flowers were maintained at room
temperature under continuous light and a light intensity of 0.85 mW/cm² provided by two 40-W
Grolux lamps.

Treatments.—One-third of the flowers were self-
pollinated. Auxin (25 g NAA per flower) was applied in 5 µl drops of warm liquefied lanolin to the
stigmata of flowers of a second group. Untreated flowers served as controls, since lanolin had no sig-
nificant effects in previous studies (ARDITTI and
KNAUFT 1969; ARDITTI, FLICK, and JEFFREY 1971a;
ARDITTI et al. 1971b).

Sampling.—Flowers were harvested 0, 3, 8, 24,
48, 96, and 168 h after the treatments (HARRISON
and ARDITTI 1976) and divided into gynostemia
(columns, one per flower), ovaries (one per flower),
dorsal (median) sepals (one per flower), lateral sepals
(two per flower), petals (two per flower), and
labella (lips, median sepals; one per flower). The
segments were weighed while fresh, dried at 80 C
for 24 h, and reweighed. In preliminary experiments,
longer drying periods did not result in additional
weight losses. Initial weights were obtained from 10
freshly cut untreated flowers. Results were uniform
and are presented as FW, DW, and HV (figs. 1-4)
and percentage of gain (+) or loss (-) at the end of
the experiment (table 1). All treatments were repli-
cated nine times.

Results

Untreated flowers.—The DW of all segments
increased (figs. 1a, 2a, 3a, 4a; table 1). Gains in the
perianth were smaller than in the gynostemia and
ovaries (table 1). After 24 h, the DW of all segments
had increased; it dropped at 48 h and did not change very much thereafter (figs. 1a, 2a, 3a, 4a).

Labella (fig. 3b) and sepals (fig. 4b) showed no FW changes, but petals (table 1) and ovaries (fig. 2b) gained. Gynostemia (fig. 1b) lost FW slightly. Gains in FW by the gynostemia and ovaries were 5 times higher than those of the perianth (table 1).

Except labella, all floral segments decreased in HV (table 1). Following a drop at 24 h, HV of ovaries (fig. 2c) and labella (fig. 3c) increased, but by the end of 168 h still showed a loss. Petals, which behaved like the other perianth segments, as exemplified by dorsal sepals (fig. 4c), decreased in HV at 24 h, increased during the next 72 h, and then dropped again. The HV of columns (fig. 1c) decreased during the first 24 h and did not change thereafter.

Pollinated flowers.—Small DW gains were
TABLE 1

<table>
<thead>
<tr>
<th>Flora segments</th>
<th>Initial weight, g</th>
<th>Control</th>
<th>Pollinated</th>
<th>NAA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FW</td>
<td>DW</td>
<td>HV</td>
<td>FW</td>
</tr>
<tr>
<td>Labellum (lip)</td>
<td>1.5</td>
<td>.16</td>
<td>8.4</td>
<td>14.5</td>
</tr>
<tr>
<td>Ovary</td>
<td>.95</td>
<td>125</td>
<td>6.6</td>
<td>43.8</td>
</tr>
<tr>
<td>Gynostemium</td>
<td>1.4</td>
<td>.185</td>
<td>6.57</td>
<td>37.0</td>
</tr>
<tr>
<td>Lateral petals</td>
<td>1.4</td>
<td>.14</td>
<td>9.0</td>
<td>-6</td>
</tr>
<tr>
<td>Dorsal sepals</td>
<td>1.15</td>
<td>.14</td>
<td>9.45</td>
<td>20.9</td>
</tr>
<tr>
<td>Labellar petals</td>
<td>1.85</td>
<td>.195</td>
<td>8.48</td>
<td>17.2</td>
</tr>
<tr>
<td>Labellum</td>
<td>2.9</td>
<td>.3</td>
<td>8.67</td>
<td>2.9</td>
</tr>
<tr>
<td>All sepals</td>
<td>3.0</td>
<td>.305</td>
<td>8.83</td>
<td>13.1</td>
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<tr>
<td>Entire perianth</td>
<td>5.9</td>
<td>.695</td>
<td>8.75</td>
<td>14.1</td>
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<tr>
<td>Gynostemium</td>
<td>+1.4</td>
<td>10.7</td>
<td>-9.3</td>
<td>17.4</td>
</tr>
<tr>
<td>Ovary</td>
<td>2.35</td>
<td>.31</td>
<td>6.38</td>
<td>6.9</td>
</tr>
<tr>
<td>Whole flower</td>
<td>8.25</td>
<td>.915</td>
<td>8.91</td>
<td>9.1</td>
</tr>
</tbody>
</table>

* One per flower.  
* Two per flower.  
* A total of three.

Discussion

UNTREATED FLOWERS (CONTROL).—The DW increases in all segments and the entire flower indicate dry matter (sugar, minerals) uptake from the culture medium. Photosynthesis may occur in green Cymbidium flowers (DUEKER and ARDITTI 1968), but in this flower the perianth was white. Ovaries (the only green segments) were essentially in the dark because of the position of the tubes inside the small cans. The increases in DW and losses in HV during the first 24 h also indicate dry-matter uptake regardless of water movement. Similar uptake of sucrose, fluoride (as Na+), and red dye has been reported for Gladiolus, Gerbera, Chrysanthemum, and snapdragons (Marousky 1971, 1972; Marousky and WOLTZ 1975).

The DW losses by all segments between 24 and 48 or 96 h may be the result of reduced uptake and increased utilization, or a combination of the two. Although firm evidence is not available, it appears reasonable to assume that the increased utilization is through respiration. Reports regarding respiration in orchid flowers support this assumption despite lower rates in older blossoms (HSIANG 1951b; SHEEHAN 1954; ROSENSTOCK 1956). Our findings (Harrison and ARDITTI 1976) showed that leakage (at least of 3P) into the medium does not occur.

Life of Cymbidium flowers exceeds 1 wk. Therefore, it is not surprising that at the end of 7 days the flowers gained in DW (figs. 1a, 2a, 3a, 4a; table 1). The transpiration stream (GLÖDSCHMIDT and HUBERMAN 1974) results in the uptake and accumulation of minerals and sugars from the medium. We have no evidence for active uptake.

Increases in FW (except in the labellum) after 24 h are the result of higher water uptake brought about by elevated osmotic concentrations which have been reported in orchid flowers (HSIANG 1951a). Reduced subsequent water uptake, increased transpiration losses, or a combination of the two can account for the low final FW (table 1). The sizable FW gains by ovaries (fig. 2b; table 1) are due both to water uptake and the fact that they were either submerged in medium or inside the tubes where transpiration is reduced.

Water losses occur through cuticular transpiration...
in the absence of stomata on the perianth of Cymbidium flowers (Hsiang 1951a).

**Pollinated flowers.**—As in control flowers, gains in DW during the first 24 h are due to uptake of solutes from the medium. Uptake is also a contributing factor to the subsequent DW increases in gynostemia (fig. 1a) and ovaries (fig. 2a). One suggestion (Fitting 1909a, 1909b, 1910; Schumacher 1931; Seshagirirah 1941; Gessner 1948; Harrison and Arditti 1976) is that at least part of the increase is due to transport of substances from the perianth. Our data support this view with respect to the sepal losses (table 1).

The DW gains by the entire flower (14.7%) and petals (2.7%) were much lower than those by the ovaries and gynostemia (42.5%). Losses in DW by all sepal losses (1.9%) were minimal (table 1). These figures indicate that (1) uptake from the medium does take place, and (2) substances are transported preferentially into gynostemia and ovaries which act as sinks because of newly initiated developmental processes and increased metabolic activity. Selective transport has been reported for 3P in Cymbidium (Oertli and Kohl 1960; Harrison and Arditti 1976) and tomato (Arnon, Stout, and Siapos 1940) flowers as well as for 14C sucrose, 14C-acetate, and 3H-acetate in Citrus sinensis ‘Shamouti’ blossoms (Goldschmidt and Huberman 1974). Creation of sinks in pollinated orchid flowers is evident (Fitting 1909a, 1909b, 1910; Schumacher 1931; Hubert and Maton 1939; Seshagirirah 1941; Duncan and Curtis 1942a, 1942b, 1943; Gessner 1948; Hsiang 1951a, 1951b; Rosenstock 1956; Heslop-Harrison 1957; Oertli and Kohl 1960; Harrison and Arditti 1976).

All perianth segments should lose DW if there is transport of dry matter from them into columns and ovaries. However, this is not the case. Labella (fig. 3a) and petals gained very slightly (table 1). Uptake from the medium, translocation patterns, and physiological differences between perianth segments can account for this apparent anomaly. In situ translocation of sugars into flowers is in the phloem, but distribution of substances taken up through cut peduncles or pedicels may be via the xylem (Goldschmidt and Huberman 1974). Should this be true for Cymbidium flowers, the increased transpiration stream into perianth segments will bring in a higher amount of solutes. This would lead to dry-matter accumulation and gains in DW.

As can be expected in a wilting tissue, all perianth segments lose FW (figs. 3, 4; table 1). A similar decrease in the weight of cut rose flowers occurs when transpiration is greater than water uptake (Mayak et al. 1974). Water balance is considered to be an important factor in the determination of cutflower longevity (Mayak et al. 1974). Our results confirm this by demonstrating that pollinated or auxin-treated flowers (which senesce and die quickly) show higher FW losses than unpollinated ones (which age and die at a slower rate). The FW gains by gynostemia (fig. 1b) and ovaries (fig. 2b) result from the increased water content which is also the reason for their swelling (Hubert and Maton 1939).

Perianth segments (figs. 3c, 4c; table 1) become drier and have a lower HV because water losses are proportionally higher than those of dry matter. The reduced HV of gynostemia (fig. 1c) and ovaries (fig. 2c) is due to a disproportionately higher influx of water than that of dry matter.

**NAA-treated flowers.**—Auxins, including NAA, can mimic pollination or emasculation in orchid flowers. The overall effect is accelerated aging, sometimes, as observed here, even more than after pollination (Fitting 1909a, 1909b, 1910; Hubert and Maton 1939; Gessner 1948; Hsiang 1951a, 1951b; Burg and Dijkstra 1967; Dolcher 1967; Arditti and Knauf 1969; Arditti et al. 1971a, 1971b). Hence FW and DW losses in perianth segments of NAA-treated flowers may be higher than those of pollinated blossoms. The NAA application mimics pollination in respect to DW of gynostemia (fig. 1a) and FW of perianth segments (fig. 3b, 4b; table 1), but not in ovaries.

Pollination initiates ovule formation in orchid ovaries, but auxin applications do not always have the same effect. Thus, NAA-treated ovaries may be senescing, and this is reflected in their FW, DW, and HV (fig. 2; table 1). In gynostemia these differences between pollination and NAA treatment may be due to (1) faster destruction of IAA (the auxin found in pollen), (2) the presence of other hormones in pollinia (R. Ma, unpublished results), and/or (3) auxin-induced synthesis of other substances such as ethylene (Arditti, Hogan, and Chadwick 1973).

The observed FW, DW, and HV changes in Cymbidium ‘Jungfrau’ are fully in line with our previous observations and suggestions regarding pre- and postpollination phenomena and aging in orchid flowers. These observations also indicate that the labellum is physiologically similar to perianth segments, thereby supporting the view that it has originated from a petal (Vermeulen 1959; Nelson 1965, 1967).

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