

## Plenary Lectures

### Pollen of Araceae - form, function, and fossil history

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**Pollen Form.** Ultrastructural pollen wall characters of Araceae support the arrangement of tribes and genera in the molecular trees (e.g., Barabé et al. 2004, Cabrera et al. 2003) and confirm greatly the morphological classification by Mayo et al. (1997). Pollen walls in the subfamily Aroideae are characterized by the lack of an aperture and the absence of a stable sporopollenin outer exine layer, and by the presence of several pollen characters typical for all other aroid subfamilies.

In previous classifications the Araceae subfamilies were widely eurypalynous, but now the actual subfamilies appear to be stenopalynous. In accordance with molecular results, pollen wall characters support the placement of Lemnaceae (as new subfamily Lemnoideae) between Pothoideae and Orontioideae, and the treatment of Zamiculcas and Gonatopus - formerly the most basal Aroideae - as a new subfamily Zamiculcadoideae (Bogner & Hesse 2005).

The circumscription of Lasioideae (sensu Mayo et al. 1997) and Aroideae (sensu Bogner & Hesse 2005) is confirmed by pollen characters. The pollen aperture of Lasioideae is unique because of its multi-lamellar nature, not found elsewhere.

The by far largest subfamily Aroideae deserves a closer look. Most of the genera share a thick, spongy endexine, covered by a polysaccharide outer exine layer, which does not resist acetolysis. Moreover, a clear border-line separates the more basal tribes and genera of Aroideae with a widely smooth pollen surface from the derived Aroideae with distinct spiny pollen.

**Pollen Function.** The central question should not be overlooked. Why do most Aroideae pollen lack a sporopollenin outer exine layer and lack simultaneously an aperture? The Aroideae suffer from unusual, even spectacular losses (they have lost bisexual flowers, petals, aperturate pollen, and an elaborate sporopollenin exine). In contrast they have newly acquired chemical features (e.g., laticifers, or the polysaccharide outer exine layer). All «losses» and «new acquisitions» together are in sum a great step away from the original characters found in the more basal subfamilies of Araceae. A possible answer could be that a major change - or a major paradigm shift - in aroid evolution took place at the point when (in the Paleogene or even earlier?) «the family went unisexual», accompanied by the simultaneous loss of important anatomical features and simultaneously new acquisitions of protecting chemical features.

Two benefits from a loss of sporopollenin tectate-columellate exine and the new acquisition of a polysaccharide layer in the Aroideae are discernible. A first benefit of such a

dramatic exine modification and reduction is the environmental factor. The reduced exines in omniaperturate pollen grains may be an adaptation to many angiosperm species living in moist or even wet environments where pollen is not subject to desiccation or to other harmomegathic stresses. The hypothesis is that in Aroideae the extremely reduced, unstable, easily rupturing non-sporopollenin outer exine layer facilitates to a greater extent the pollen tube formation.

A second benefit of the drastic exine modification is its character of being an adaptive prerequisite of the specialized pollination biology in many Aroideae, or more precisely being the consequence of it. The hypothesis is, that ephemeral spathes and absence of a sporopollenin ektexine are the consequence of an adaptive syndrome for a short pollination time window in those Aroideae, where short-living pollen, rapid germination and brief receptivity of stigma work together. Therefore, a stable exine is not necessary from the economic standpoint (it is energetically costly to produce sporopollenin), and a somewhat elaborate sporopollenin layer is obstructive to form a pollen tube quickly under these conditions.

Fossil History. The fossil pollen record of Araceae was up to recent extremely sparse, consisting of a single record of a polypllicate pollen form (*Spathiphyllum*) from the Late Miocene (c. 20 My). An outer exine layer not resistant to acetolysis as in most Aroideae means that such pollen grains would be either not become fossil, or would be found as smooth, indifferent bodies. However, a stable sporopollenin ektexine is common in the other aroid subfamilies. Recent findings of unequivocal Araceae pollen types attributable to several subfamilies have enhanced the fossil record greatly. In various fossil assemblages, based on comparison with extant taxa, three distinctive Araceae pollen types with an elaborated sporopollenin ektexine have been found: an inaperturate-polypllicate type from the late Early Cretaceous (Friis et al. 2004), a zona-aperturate-foveolate type from the Latest Cretaceous to the Paleogene (Zetter et al. 2001), and an ulcerate-spiny type from the Paleogene (Stockey et al. 1997, Hesse & Zetter, in press). The fossil history now starts with the late Early Cretaceous (c. 120 My). By the Latest Cretaceous to the Paleogene distinctive Araceae pollen types provide clear evidence that several Araceae lineages have developed since the Cretaceous becoming diverse in the Paleogene, when the family «went unisexual».

#### References:

- BARABÉ, D., LACROIX, C., BRUNEAU, A., ARCHAMBAULT, A. & GIBERNAU, M. 2004. Floral development and phylogenetic position of *Schismatoglottis* (Araceae). *Int. J. Plant Sci.*, 165(1):173-189.
- BOGNER, J. & HESSE, M. 2005. *Zamioculcadoideae*, a new subfamily of Araceae. *Aroideana*, 28:3-20.
- CABRERA, L.I., SALAZAR, G.A., CHASE, M.W. & MAYO, S.J. 2003. Phylogenetics of Araceae and Lemnaceae: evidence from multiple plastid DNA data sets. Third International Conference on the Comparative Biology of the Monocotyledons, Ontario, California. Abstract, p. 11.
- FRIIS, E.M., RAUNSGAARD PEDERSEN, K. & CRANE, P.R. 2004. Araceae from the Early Cretaceous of Portugal: evidence on the emergence of monocotyledons. *PNAS* 101: 16565-16570.

- MAYO, S.J., BOGNER, J. & BOYCE, P.C. 1997. The Genera of Araceae. Royal Botanic Gardens, Kew.
- STOCKEY, R.A., HOFFMAN, G.L. & ROTHWELL, G.W. 1997. The fossil monocot *Limnobiophyllum scutatum*: resolving the phylogeny of Lemnaceae. *Amer. J. Bot.*, 84: 355-368.
- ZETTER, R., HESSE, M., FROSCH-RADIVO, A. 2001. Early Eocene zona-aperturate pollen grains of the Proxapertites type with affinity to Araceae. *Rev. Paleobot. Palynol.* 117: 267-279.

## Métodos fenológicos recientes aplicados a la Aerobiología

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La fenología trata sobre el estudio de los eventos biológicos que ocurren de forma periódica así como su influencia por el ambiente, especialmente cambios en la temperatura provocados por el tiempo y el clima (Schwartz, 2003).

Aerobiología y fenología son disciplinas complementarias. La aerobiología, y en concreto la aeropalinología, permite cuantificar cambios en la fenología floral de plantas anemófilas. Por otro lado, los estudios fenológicos de campo son de gran interés para predecir e interpretar los datos aerobiológicos sobre el contenido de polen en el aire.

En los últimos años se ha incrementado el interés por esta ciencia integradora debido a que se considera que las bases de datos fenológicas ofrecen una importante información acerca del impacto del cambio climático en la fenología reproductora y morfológica de las diferentes especies, así como en su biodiversidad. Las bases de datos aerobiológicos ofrecen información detallada sobre la fenología reproductora de especies anemófilas. Este interés está conduciendo hacia una mayor valoración de los métodos tradicionales de fenología y al desarrollo de nuevos métodos y aplicaciones de la fenología que están mejorando la interpretación de los resultados aerobiológicos.

Las bases de datos fenológicas están siendo cada vez más solicitadas por investigadores de diferentes disciplinas en biología. Las bases de datos históricas permiten establecer calendarios fenológicos que indican los cambios biológicos a través del tiempo. El uso de los datos aerobiológicos permite obtener datos diarios numéricos y objetivos sobre el contenido diario e incluso horario de polen en el aire. Esta información complementa a la que se obtiene a partir de datos fenológicos de campo, que se suelen tomar una o dos veces a la semana provocando que las diferentes fases fenológicas sean estimadas por interpolación lineal para ofrecer los datos diarios.

Tanto las variables meteorológicas como las feno-climáticas se suelen utilizar para ajustar los modelos fenológicos locales, con la posibilidad de obtener modelos y predicciones a nivel regional.