Biol. Rundsch. **28**, 83-86 (1990)
VEB Gustav Fischer Verlag Jena

Short Original Release

Spadix-bearing parasites (Balanophoraceae): Extreme flowering plants with fungal character

By HANS CHRISTIAN WEBER and SUNARYO

Summary

Balanophoraceae: Extreme flowering plants of fungal characteristics

Balanophoraceae are extremely progressive parasites. Because of the difficulty to collect materials of *Balanophora* and because there was no success until now to culture it, the knowledge about its germination and development is very littIe. We studied *Balanophora elongata* Bl. in Java, collected the roots of the host *Vaccinium lucidum* (Ericaceae), and examined anatomically the seeds and its penetration. In its structure, the penetrating *Balanaphora* seedling looks more like a penetrating fungus spore than a stage of a fIowering plant. These seedlings are extremely reduced and without forming a haustorium, the embryo penetrates the host tissue directly unlike as is usual for parasitic flowering plants. The advantage of this strong reduction of the seedling's development for the parasite is discussed.

Nutritional specialization in flowering plants resulted in the course of phylogenetic development of more advanced forms to extraordinary modifications of the corm. Witnesses to this are the parasites, i.e. plants that invade by means of haustoria for the purpose of feeding on living host tissue (1). From the local floral kingdom, these include for example the devil silk (*Cuscuta*), the broomrape (*Orobanche*) or our mistletoe (*Viscum*). They are characterized namely by the loss of chlorophyll, foliage leaves or roots.

Even more modified parasites can be found in non-European countries. For example, the Balanophoraceae with around 100 species from 18 genera (Fig. 1). The plants are mainly distributed in the tropics of the Americas, Asia, Africa and Oceania. Despite its bizarre manifestations (2, 3) especially the species of rainforests have been scientifically comparatively neglected (4), not least because of the arduous material procurement. It is therefore no wonder that only a few authors to this day comment on these plants (5, 6) and, consequently, our knowledge about their development and life is deficient.

As part of a larger study on the biology of Balanophoraceae, we therefore want the following first - as we think, remarkable - submit our findings on seed germination. A documentation of this first step (7) of the mode of development is in these plants far more difficult than, on the one hand, with selective breeding under controlled conditions, and on the other hand, in the natural ground locations of the tiny, approximately 0.1 mm in diameter large seeds (Fig. 2) which are hardly visible to the naked eye.

We conducted our studies at the natural sites of *Balanophora elongata* Bl. in Java. In addition to numerous soil samples, mainly roots of candidate host plants were fixed in FAA. These were then later carefully cleaned in the laboratory and prepared; with the aid of a binocular microscope, we then investigated their surfaces.

On the young roots of *Vaccinium lucidum* (Ericaceae), a frequent associated plant of *B. elongata*, we found numerous firmly attached globules (Fig. 3) with diameters of about 0.15 mm. It was here not what one might initially assume, larger spores of parasitic or symbiotic fungi, but rather the seeds of *Balanophora*.

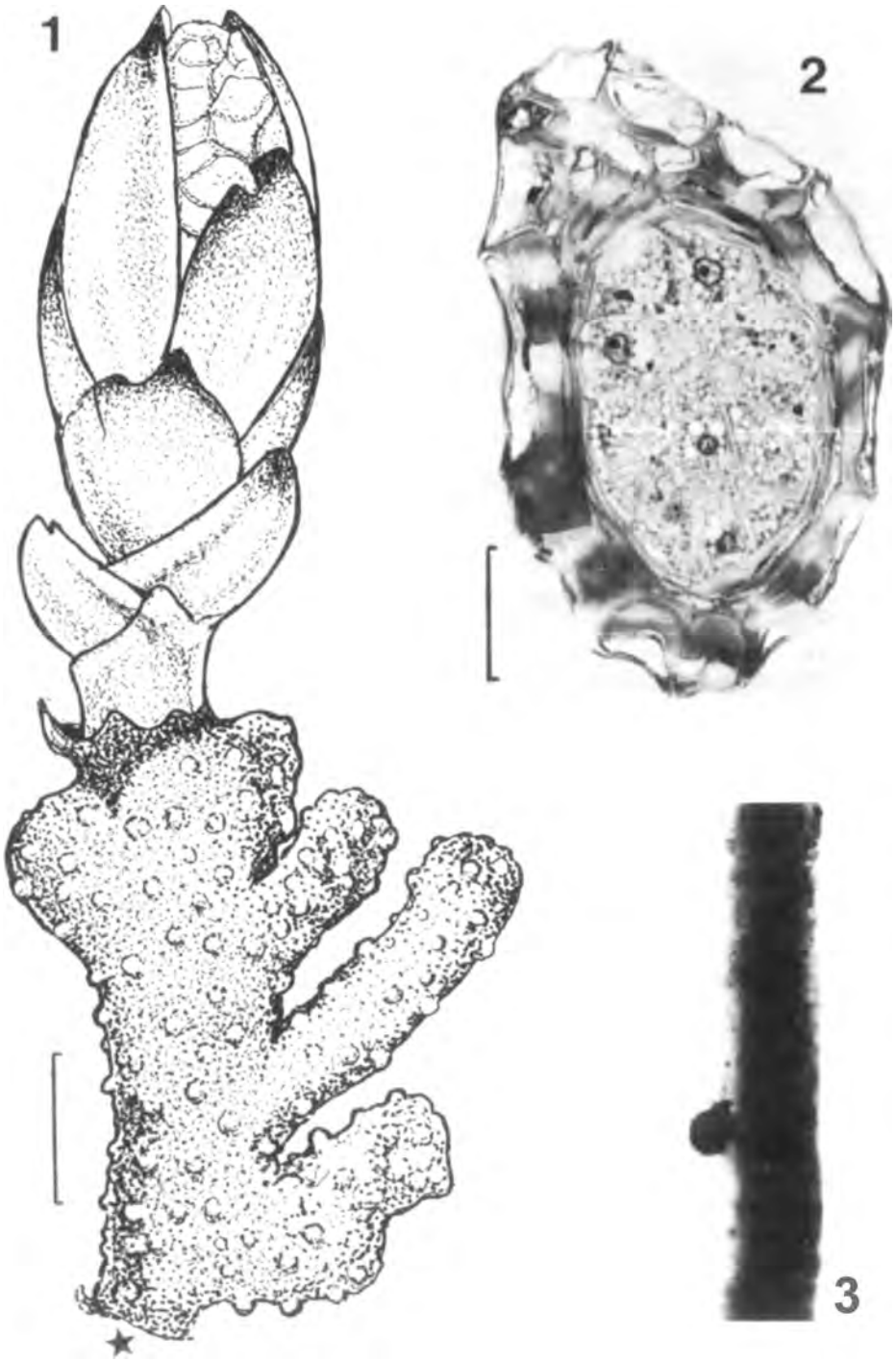

Fig. 1. *Balanaphora elongata*. Male inflorescence of tuber (* former contact parts of this remote host root). Scale corresponds to 1 cm.

Fig. 2. *Balanophora fungosa* ssp. *indica* (Arn.) B. HANSEN. Cross section through the ovary with 1 seed. Scale corresponds to 0.05 mm.

Fig. 3. *Balanophora elongata*. Same on a thin host root (*Vaccinium*). Scale corresponds to 0.5 mm.

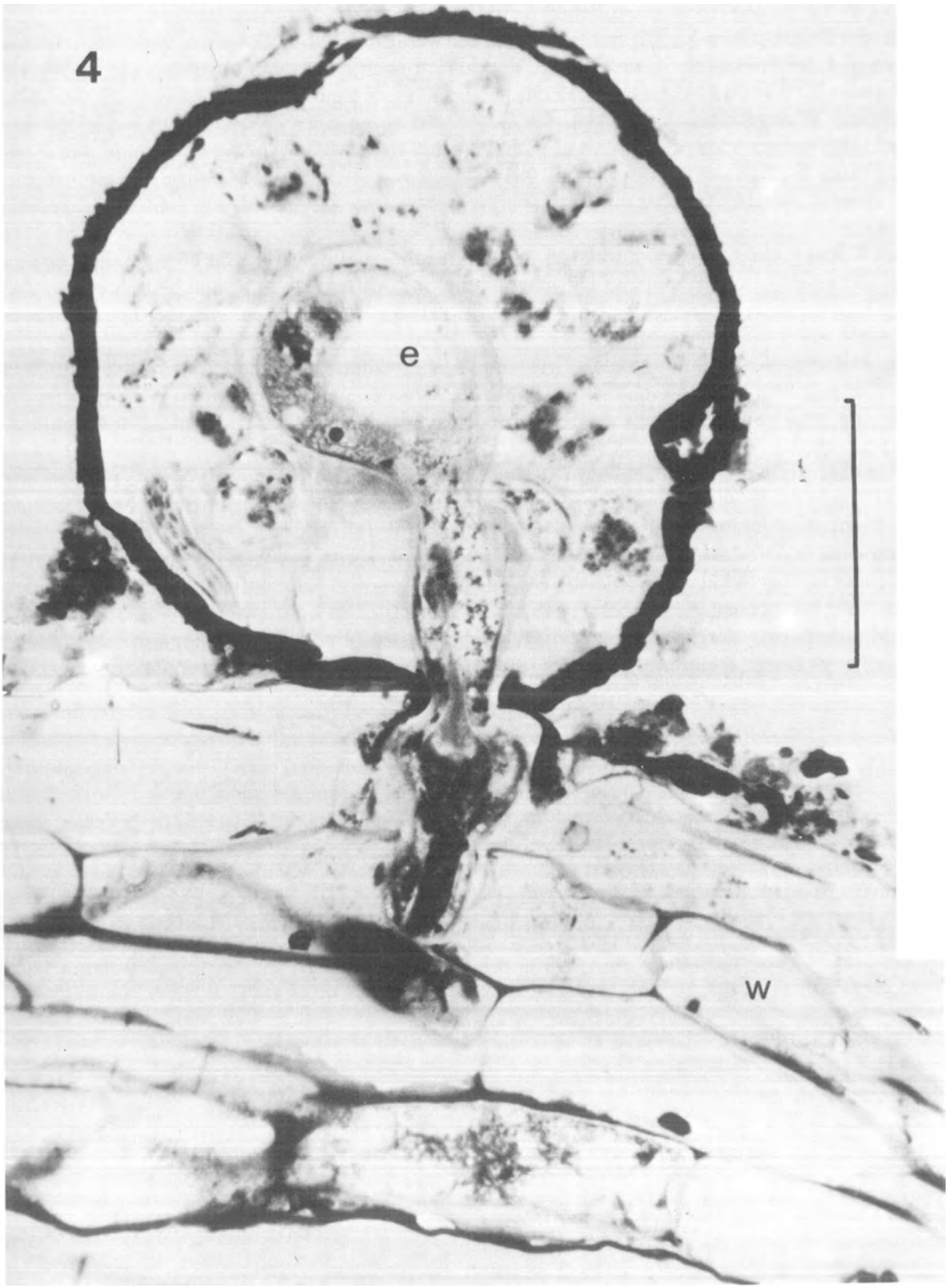

Fig. 4. *Balanophora elongata*; the host tissue (w) is penetrated by parasitic cells of the disintegrating endosperm surrounding the embryo (e). Scale corresponds to 0.05 mm

After an embedding of such root portions of the Ericaceae in historesin and the preparation of 3 microns thin sections, we confirmed via microscopic examination that it is the young slightly swollen seedling stages of the parasite.

The small *Balanophora* seeds are composed of only a few-celled endosperm, an undifferentiated embryo and the seed coat. Probably after the outflow of a suitable root stimulant, a cell series which consists of the embryo axis swells slightly, and then stretches in the direction of host tissue. Unlike other parasites with similar modes of development, here there is not now a massive swelling and thus the formation of a clearly visible primary contact organ, which penetrates into cells of the host. This *B. elongata* is rather comparable to the mushroom penetration process that is performed immediately (Fig. 4).

With the formation of such an intrusive section of the “seedling” it only now at this time that it starts to conduct proper tissue formation and differentiation, so that now comes to light the peculiarities of higher organized plants, which we, however, want to address in detail at this point.

Since the plants of the Balanophorales, as mentioned above, must be classified according to their morphological variations with the most derived parasites, the consideration of the benefits remains from this first appearance as regressive germination.

Before other similar parasites (8) can attack tissue of their hosts, they must first set ground tissue. This critical phase, influenced more by environmental factors, not only lasts longer, it is also much more energy consuming. In contrast, our *Balanophora* leaves the protective seed coat and immediately penetrates the host, so that once again rapid protection is ensured so that other nutrients can immediately be taken up. We refer to this highest form of parasitic lifestyles as endoparasitic. With the first stage of development shown here by *Balanophora* through an extremely reduced seedling, a further step towards perfecting endoparasitism is shown.

Literature

1. WEBER, H. CHR., Wurzelparasitismus terrestrischer Blütenpflanzen, Habilitation, Ulm 1982. - 2. VISSER, J. H. South African Parasitic Flowering Plants, Juta & Co, Cape Town 1981. - 3. HANSEN, B., The Genus *Balanophora* J. R. & G. Forster. A Taxonomic Monograph. Dansk Botanisk Ark iv, Nr. I, 1972. - 4. KUBAT. R., and C. NIYOMDHAM, Balanophoraceae and Rafflesiaceae of Thailand, in: WEBER, H. CHR. and W. FORSTREUTER (Eds.) Parasitic Flowcring Plants, p. 493-496, Marburg, F.R.G., 1987. - 5. KUIJT, J., The Biology of the parasitic flowering plants. Berkeley, Los Angeles 1969. - 6. WEBER, H. CHR. Granulahaltige Xylem-Leitbahnen und andere den Santalales ähnliche anatomische Strukturen in den haustorialen Knollen von *Mystropetalon thomii* Harv. (Balanophoraceae), Flora 178. 315-328 (1986). - 7. GOVINDAPPA, D. AREKAL and G. R. SHIVAMURTHY. "Seed" Germination in *Balanophora abbreviata*, Phytomorph. 26, 135-138 (1976). - 8. WEBER, H. CHR., and W. FORSTREUTER (Eds.), Parasitic Flowering Plants (Proc. 4th Int. Symp. Parasitic Fl. Pl). Marburg. F.R.G., 1987.

Author's address:

Professer Dr. HANS CHRISTIAN WEBER and Dipl. -Biol. Sunaryo. Philipps-University Marburg, Department of Biology - Botany, Lahnberge. D - 3550 Marburg

(The editors received on October 4, 1989)