Vasculature in the carpels of *Belliolum pancheri* (Winteraceae)

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植田邦彦：*Belliolum pancheri* の心皮における維管束走向について

The carpels of the Winteraceae have been much investigated from both morphological and phylogenetic points of view. The carpels of the genus *Tasmannia* were interpreted as being the most primitive, conduplicate-unsealed carpels vascularized by two ventral strands and a more or less bifurcate dorsal strand (Bailey and Nast, 1943, 1945; Bailey and Swamy, 1951). According to Tucker and Gifford (1964), the carpels of *T. lanceolata* were supplied by two dorsal strands from two sympodia in the receptacles and two ventral strands which were the extensions of two or one sympodium. At the same time they showed the diversity of the vasculature and emphasized observations of both the vasculature of the carpels and those of the receptacles after the branching off the stamen traces.

Bailey and Nast (1943) considered that the ovules of the Winteraceae were supplied by the strands contributed by both the ventral and dorsal strands as well as by the dorsal strands only or by the ventral strands only, and that these anatomical features were primitive ones. On the other hand, Tucker (1975) investigated ontogenetically the vasculature of the carpels of *T. lanceolata* and *Drimys winteri* var. *chilensis* and came to the conclusion that the vasculature reported by Bailey and Nast rarely occurred and that the contributions from the dorsal strands came late in the development of the carpels.

The carpels of *Belliolum pancheri* (Baill.) van Tieghem were observed with reference to the placentation by Leinfellner (1966b) who regarded it as "U-förmige Plazenta," but the vasculature has not been observed. In the present paper the morphology and anatomy of the carpels are described and a comparison is made between *B. pancheri* and the other species and genera of the Winteraceae hitherto observed.

**Materials and Methods**

Large flower buds, flowers and very young fruits of *B. pancheri* were collected by myself at the National Plant Reservation in Yate Plain, New Caledonia, on 29 August, 1976.

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They were fixed in 1:3 acetic acid-70% ethyl alcohol solution. The materials were dehydrated through an n-butyl alcohol series and embedded in paraffin. The sections were cut at a thickness of 10–15 \( \mu \)m and stained with safranin or basic fuchsin (safranin gives more conspicuous staining). More than fifteen carpels were observed in this way. There are numerous scleride-like substances in the carpels so that the vasculature cannot be observed in cleared materials prepared by usual methods. The vasculature is, therefore, reconstructed from the serial sections only. The voucher specimens, N. FUKUOKA et al., No. c-139, are kept at KYO and duplicates have been sent to L, P and A.

**Observations**

Two to seven (usually 4–5) carpels are inserted nearly terminally on the receptacle in each flower. The large stigmatic crests are situated at the subadaxial side of the distal part of the carpels. The stigmatic crests are sensitive for safranin at the same level as the ventral suture lines and the deposits of tannin observed in the walls of the carpels (Fig. 3–1). The ventral stuture which is observed between the stigmatic crest and the loculus is recognized barely as a line composed of two or one row of cells (Fig. 3–2). The loculus is oblong to spindle in shape and its longitudinal axis is parallel to the stigmatic crest. The bases of the stipes of the carpels are swollen inwardly and cohere to one another, but are never connate, so that the terminal region of the receptacle is covered with the coherent

![Diagram](image-url)

Fig. 1. Diagrammatic illustration of the carpellar traces in the receptacle at successively higher levels. 1: just above all the stamen traces departing. 5: just below carpellar stipes. 6: bases of carpellar stipes. A–E: carpels. SD: subdorsal strands.
parts of the stipes. Eight or ten ovules are arranged in two rows in each carpel.

*Carpel traces* in the receptacle—After departure of the stamen traces from the stelar strands there still remain 10–18 residual stelar strands. Each dorsal strand is usually the direct extension of a stelar strand, as shown in Fig. 1 as 1, 2", 4, 6 and 9. However, there are some deviations: 2' and 2" diverge from a single strand, 6 anastomoses with 7 as well as with a branch of 5, and 9 gives off a small branch. The stelar strands, other than those going as the dorsals, either anastomose and assemble to form enlarged strands or run up through the central region. In some cases, the strands join to those opposite them to form a cross connection in the center of the receptacle (Fig. 1). Anastomosing with 10, strand 2' fuses with 3' and forms the ventral strand of carpel A. Strand 3" enlarges variously in cross-sectional view and anastomoses with various strands. A ventral strand of carpel B branches off from a portion of that enlarged strand. Strand 5 branches a few

* The term "trace" is used in this paper after Nast (1944).
times, the branches then uniting with each other to form the ventral strand of carpel C. Strands 9, 10 and 2' unite with each other, giving off the ventral strand of carpel D. Strand 10 anastomoses with 9 and 2' and forms the ventral strand of carpel E. A subdorsal strand is formed in the same way as the ventral strand and approaches the dorsal strand in the lower portion of the carpellary stipe. The laterals are formed in a few cases as the subdorsal strand. They ascend through the carpel wall and anastomose with wall strands at various levels.

Vasculature in the carpel—The carpel is supplied by 2 or 3 strands: one ventral, one dorsal and/or one subdorsal strand. Each ventral and dorsal strand has one protoxylem up to a level near the lowermost pair of the ovules in the present materials (Fig. 2), and rarely two protoxylems, but each of them is never two strands in the carpel. The ventral strand bifurcates near the placenta of the lowermost pair of ovules, giving rise to two strands at the level of the next ovules. The two strands gradually approach each other near the level of the uppermost part of the placenta and unite above it (Fig. 2). There is the rib-shaped dorsal strand accompanied with wall strands which are divided from the dorsal strand. The dorsal strand branches off a lowermost wall strand near the same level as the lowermost placenta. The other wall strands, which are branched from the dorsal strand at successive levels, run obliquely and nearly in parallel through the carpel wall. After divergence of the wall strands, the dorsal strand and the two uppermost wall strands

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Fig. 3. Cross view of the carpel. 1: bottom of loculus. 2: showing ventral suture, uppermost pair of ovules and two ventral strands. 3: "central" ovule 4: lowermost pair of ovules at 30 μm higher level of 3. 'c'O: "central" ovule. L: loculus. oO: ovule of opposite row. S: sclereid. T: tannin deposit. V: ventral strand. VS: ventral suture. ×120.
connect with the ventral strand at the level where the ventral strands anastomose. The ventral strand and the dorsal strand form a "ring" parallel to both the stigmatic crest and the loculus between them. The subdorsal strand, when present, runs in parallel to the dorsal strand and is bent obliquely as the wall strand.

**Ovular vascular supply**—All ovules are supplied by strands contributed by both the ventral and the wall strands (Fig. 4). They are supplied by the strands, in the young carpel, whose wall strands are not yet differentiated: procambial strands. The ovular supplies in the mature carpel are usually obscure and still procambial strands in rare cases. In other cases either of the branches of the ventral strands and the wall strands may be procambial, both are procambial, or both are obvious. Thus the ovular supplies become differentiated even in mature carpel and in very young fruit.

**Placentation**—As mentioned above, the ovules are situated along two rows of placenta as seen in Fig. 2, 3–4 and 4. In some carpels, there seems to be a "central" ovule in the lowermost space of the loculus. The funicle of the "central" ovule, however, is attached to the placenta at the same level as the portion of the placenta to which the lowermost ovule of the other row is attached (Fig. 3–3, 3–4). A pair of lowermost ovules arranges alternately in appearance in such cases.
Discussion

Tucker (1975) reported that there is no lowermost central ovule in the carpel of Tasmania lanceolata and Drimys winteri var. chilensis and criticized the "U-förmige Plazenta" interpreted by Leinfellner (1965, 1966a) in these two species. As the conclusion of Tucker, the placentation of Belloilum pancheri is not U-shape but the ovules arrange in two rows even in the lowermost level in all cases observed. The appearance of the "central" ovule results from the narrow space of the lowermost part of the loculus.

Bailey and Nast (1943) noted the occurrence of the strands supplied by the dorsal strands as well as the ventral strands contributing to the ovules in many species of the Winteraceae and considered such a pattern of supply as a primitive feature. Contrary to their hypothesis, Tucker (1975) observed the ontogeny of the carpels of T. lanceolata and D. winteri var. chilensis and concluded that such a pattern of ovular supply, if any, is not fundamental, at least in these two species, and emphasized re-examination of the concepts of contribution by the dorsal strand to the ovular supply. In this observation of B. pancheri the ovules are supplied by the strands contributed by both the ventral and dorsal strands. In young carpels, the ovules appear to be supplied by the ventral strands only, though there are procambial wall strands supplying the ovular strands. The same condition may exist in T. lanceolata and D. winteri var. chilensis, as Tucker referred to those conditions as resulting from various development of both strands.

In regard to the pattern of the carpellary traces in the receptacle, i.e., many residual stelar strands and dorsal traces departing from the stelar cylinder first, B. pancheri resembles Bubbia, Pseudowintera and the Solomon Belloilum in various degrees as observed by Nast (1944), but does not resemble Drimys and Tasmania. The ventral strands are a single strand in the carpels formed from 2–4 stelar strands; the dorsal strands consist of a single strand as the direct extension of a stelar strand. In this feature, B. pancheri is quite distinct from the other Winteraceae species which have a bifurcate or two ventral and dorsal strands (Bailey and Nast, 1943; Tucker and Gifford, 1964). As seen in Fig. 1, however, the vasculature of the carpels, as a whole, much resembles that of several species of Bubbia and Pseudowintera colorata (Bailey and Nast, 1943; Bhandari, 1963).

Summary

The carpels of Belloilum pancheri were observed anatomically. Each of the dorsal and ventral strand of the carpel is a single strand. The ovules of mature carpels and very young fruits are supplied by anastomosed strands contributed from both ventral and dorsals. The ventral strand is complicated to form, in various ways, from 2–4 stelar strands, though the dorsal strand is formed directly from a stelar strand.

"Central" ovules and "U-förmige Plazenta" interpreted by Leinfellner were not observed in this study.
Carpels are apparently apocarpous, but the bases of the carpellary stipes are coherent to one another and cover the terminal region of the receptacle.

I would like to thank cordially Prof. K. IWATSUKI and Prof. M. HOTTA of Kyoto University and Prof. M. TAMURA of Osaka University for their advice and encouragement throughout this study. My grateful thanks are also due to Dr. W. VINK, Leiden, who kindly identified the material. I am particularly thankful to Mr. G. TSUTSUI, Honourable Consul of Japan, New Caledonia, and Mr. A. ROGER for their kind help in the field work. Many thanks are also extended to my colleagues in the laboratory of Plant Taxonomy, Kyoto University, for their kind help in various ways. Dr. J. E. VIDAL, Paris, kindly supplied me the literature which was unavailable in Japan, and Mr. D. E. BOUFFORD, St. Luis, kindly corrected the English of this paper.

References


摘要 Winteraceae は木本性多皮 créer群に属し、熱帯から南半球にかけて分布している。8属約100種からなる科である。BAILEY らは、本科の心皮を2つ折り不完全心皮と解釈し、無導管という性質を合わせて原始的な科であると考えた。心皮については維管束走向も含めて多くの観察がなされたが、それは3属に限られていて、ここでは研究があまりなされていなかった Belliolium の心皮を、維管束走向を中心に観察した。維管束走向全体としては従来近縁とされていただるものとよく一致するが、心皮の背束・腹束が々々1本で、また心皮柄基部が互いに接着しているという注目すべき形質が観察された。また、本科の胎座をU字型とみなす報告があるが、今回観察したものは全て2列の辺縁型であった。