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VARIATIONS IN CHEMICAL COMPOSITION DURING THE DEVELOPMENT OF *HIMANTHALIA ELONGATA* (L.) S. F. GRAY

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(Text-figs. 1, 2)

Himanthalia elongata (=*H. lorea* (L.) Lyngb.), although a common brown seaweed on parts of the British coast, does not occur in sufficient quantities to render it of commercial importance. As a result, the work of Colin & Ricard (1930) appears to be the only investigation on the chemical composition of this species. Their material was collected in August 1929, but they give no indication of the size or condition of the plants which were analysed.

Seasonal variations in the chemical composition of other brown seaweeds have been studied by various workers (e.g. Lapicque, 1919; Lunde, 1940; Black, 1948*a*, *b*, 1949, 1950*a*). Also Black (1950*b*) has considered the influence of habitat and depth of immersion on the composition of three species of *Laminaria*. In these investigations no indication is given as to whether young or old plants, or sterile or fertile plants, were analysed.

After it had been shown that marked changes in chemical composition were associated with the development of the fertile receptacles in *Fucus vesiculosus* (Moss, 1950), it appeared that different growth stages of the same species collected in any one season might show variations as great as the seasonal ranges which had been reported for other species. *Himanthalia elongata* collected from two habitats, one on the west coast of Scotland and the other on the north-east coast of England, was selected for this study.

Collection of Material

One set of material was obtained from Clachan Sound, where a narrow arm of the Atlantic Ocean separates the Island of Seil from the mainland of Argyllshire. The water here is shallow, with a swift current running through, and *Himanthalia* is abundant growing amongst *Laminaria digitata* and up into the succeeding zone of *Fucus serratus*.

Collections were made on three successive days in April 1949, at low-water spring tides, when the plants were never exposed completely. Fig. 1 shows the stages into which they were sorted for chemical analysis:

Stage 1. Young sporelings up to $\frac{1}{2}$ in. in length.

Stage 2. Young sporelings more than $\frac{1}{2}$ in. in length but still with a tubular structure and no flattening of the apex.

Stage 3. Young plants with flattened apices.
Stage 4. Fully grown vegetative plants with the typical button form.
Stage 5. Buttons with young thongs (i.e. fertile receptacles) up to 10 in. in length.
Stage 6. Buttons with thongs 5–7 ft. in length.
Stage 7. Old buttons with spent receptacles which persist several months after gamete extrusion.

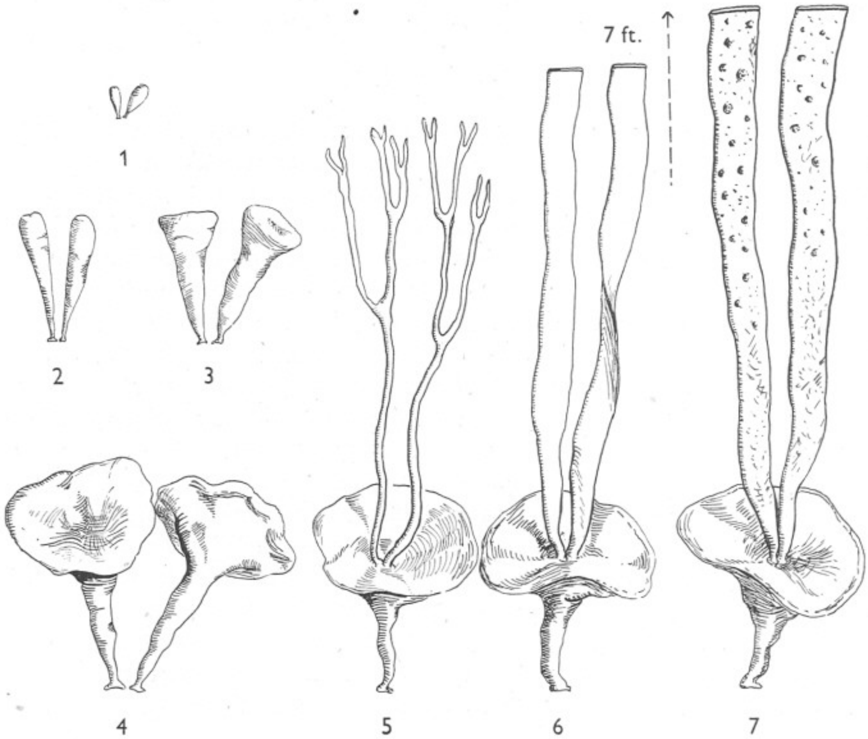

Fig. 1. Stages in the growth of *Himanthalia elongata* which were used in chemical analysis.

In the latter three stages, 5, 6 and 7, the vegetative buttons were cut from the fertile thongs and each part analysed separately, so that variations in chemical composition throughout the development of both the vegetative and fertile tissues could be studied independently.

The following April a similar series of samples were collected from St Mary's Island, Northumberland, where *Himanthalia* grows on exposed ledges, and not in association with *Laminaria* and *Fucus* as in Clachan Sound. Collections were made as the tide receded, and the plants were sorted into similar stages for analysis. However, similar developmental stages of these plants from St Mary's Island were much smaller in size than comparable stages from Clachan Sound.

The analytical methods used are those developed by the Institute of Seaweed Research (Black, 1948*a*; Cameron, Ross & Percival, 1948).

RESULTS

Dry Weight. The percentages of dry matter recorded in Fig. 2A show that an increase occurs from the sporelings to the mature plants from both habitats, but the plants from St Mary's Island always give higher values. A marked increase in dry weight occurs in the old thongs when they become hard and leathery after gamete extrusion. Such an increase was not observed in *Fucus vesiculosus* (Moss, 1950), where the receptacles disintegrate rapidly.

Mineral Ash. Fig. 2B shows the percentage total mineral ash on the anhydrous basis in plants from both habitats, while Fig. 2C gives the water soluble and water insoluble constituents of the ash in plants from Clachan Sound only.

The higher percentage dry matter of plants from St Mary's Island is associated with a lower ash content. The young sporelings from Clachan Sound have an extremely high percentage of mineral ash, 64 %, calculated on the anhydrous basis. This appears to be a higher value than any recorded for a brown seaweed. Black (1948*a*) drew attention to the high percentage of ash, 55 %, in stipes of *Saccorhiza polyschides* (Lightf.) Batt. (= *S. bulbosa* La Pyl.) collected in July 1946. The percentage dry weight of this particular sample was lower than at any other season. In a similar manner, the highest percentage ash is found in the sporelings of *Himanthalia* when their percentage dry matter is lowest.

Crude Proteins. As Fig. 2D shows, there is a gradual increase in crude proteins during the development of the vegetative buttons. The young thongs give high values, but after gamete extrusion there is a marked decrease, until the protein content of the old thongs approximates to that of the senescent buttons.

It is interesting to note that the range in crude proteins from 6·8 to 14·3 % of the dry matter of plants from Clachan Sound is identical with the seasonal range which has been published for *Laminaria digitata* collected from the same habitat (Black 1948*a*).

Mannitol and Laminarin. Fig. 2E shows the percentage mannitol, calculated on the anhydrous basis, in plants from both habitats. There is a marked decrease in the mannitol content of the vegetative buttons as the young thongs begin to grow.

Laminarin was present in very small quantities (less than 2 %) in all samples. The low values of both mannitol and laminarin may be related to the time of the year when the plants were collected, for it has been shown

(Black, 1948 *a*, *b*; 1949) that in both *Laminaria* and *Fucus* these substances are lowest during the early part of the year.

Alginic Acid. Variations in the percentage alginic acid calculated on the anhydrous basis are shown in Fig. 2 F. This substance is very low in the young

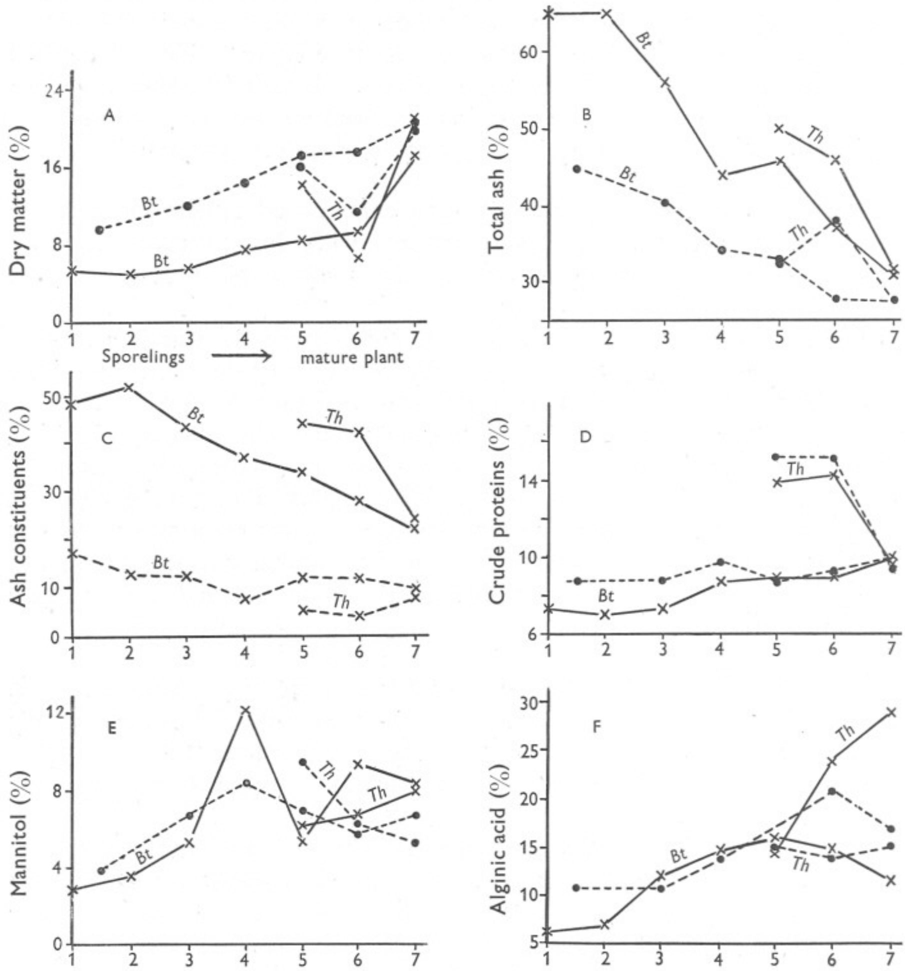

Fig. 2. Variation in chemical composition during development of *Himanthalia elongata*, expressed as percentages of weight. A, dry weight; B, total mineral ash (dry basis); C, water soluble (×——×) and water insoluble (× - - - - ×) constituents of the mineral ash (dry basis), of plants from Clachan Sound; D, crude proteins (dry basis); E, mannitol (dry basis); F, alginic acid (dry basis). *Bt*, buttons; *Th*, thongs; ×——×, plants from Clachan Sound; • - - - - •, plants from St Mary's Island.

sporelings, especially in those from Clachan Sound. The high value in the very long thongs from this habitat was not recorded in the shorter thongs from St Mary's Island.

Discussion

The young sporelings of *Himanthalia elongata*, with their very low percentage of dry matter, are also characterized by a very high mineral ash and low organic content. These young plants are growing rapidly, and as differentiation proceeds so does the percentage of organic constituents increase. The completion of vegetative activity is then followed by the rapid development of the fertile tissues or thongs. Apart from the noted decrease in mannitol, the growth of the thongs does not influence to any great extent the chemical composition of the buttons, suggesting that there is little or no storage of materials for translocation to the developing thongs.

The young thongs, being lower in mineral ash content and very much higher in proteins, mannitol and alginic acid, have a form of metabolism, as shown by their chemical composition, which differs considerably from that of young vegetative tissues developing at the same season.

While the curves obtained for plants from St Mary's Island follow the same trends as those of plants from Clachan Sound, nevertheless they do show higher percentage dry weights and lower mineral ash contents.

These analyses have shown that during the development of plants of *H. elongata* there may be a range in dry weight of 15 %, in mineral ash of 35 %, in proteins of 7 % and in alginic acid of 20 %. This emphasizes that in *Himanthalia*, as possibly in other brown seaweeds, the stage of development of the plant to be analysed is a major factor to be considered in relation to any variations in chemical composition.

Summary

Chemical analyses have been made of different stages in the growth of *Himanthalia elongata*, which have been collected at the same season from two habitats.

During the development of the vegetative buttons increases in the percentage dry weights, mannitol, crude proteins and alginic acid are found, while mineral ash decreases. The young fertile tissues or thongs are rich in proteins and alginic acid compared with the buttons which produce them.

Smaller plants from St Mary's Island have higher percentage dry weights and lower ash content, while their thongs do not show the high alginic acid content found in larger plants of a similar developmental stage from Clachan Sound.

The range in chemical constituents shown in different growth stages of the same species, collected at the same time from the same habitat, stresses the importance of describing the plant which is analysed when the effects of seasonal or other factors upon the chemical composition of brown seaweeds are being considered.

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