

CHAPTER 1

HOUSEHOLD AND PERSONAL USES



Figure 1. Mosses being sold along with fruits and vegetables in a marketplace in China. Photo by Eric Harris.

Household Uses

I think every bryologist must have been asked "what good are they?" Their small size, difficult taxonomy, and inconspicuous position in the ecosystem have caused most people to ignore bryophytes. Nevertheless, the rate at which bryophytes are being harvested from some of our national forests in North America and elsewhere suggests they are useful for something. In the high mountains of Malaysia, simply collecting mosses as a novel pillow filler (Kuen 2002) has caused vast areas of bryophyte destruction in a pristine forest. In New Zealand the small number of peatlands is diminishing from horticultural usage. In the southeastern United States, sheet mosses are removed by the truckload, and in the Pacific Northwest epiphytes are disappearing from old growth forests.

Clearly, the use of mosses is not just a tale from the past (Welch 1948; Ando 1957, 1972). In the USA today, there are about 200 "mossers" (moss growers) (Epstein 1988), a testimony that the industry has not outlived its

usefulness. The Chinese continue their tradition of using mosses and other herbals in medicines and food (Figure 1).

Furnishings

Imagine yourself in a remote village where there are no grocery stores and the nearest mall is 100 miles away by horseback. Villagers carry water on their heads, cushioned by a sirona, and bags of fruits wrapped in native moss. In your hut, you protect a fragile souvenir in a gentle bed of moss. Your mattress and pillow are stuffed with mosses. Mosses collect urine from pigs in the stall. And your child plays with a hand-made doll stuffed with moss. In these conditions, mosses take on an important role in your daily life.

Early uses of mosses can be traced as far back as the Stone-age people, who apparently used the moss *Neckera crispa* (Grosse-Brauckmann 1979; Figure 2) in a region now settled by Germany. In the French Stone Age, *Neckera crispa*, *Tortula*, and other mosses were used as we

now use sand, apparently to make the pottery less "fat," improving the quality of the pottery (H. J. During pers. comm.; Figure 3).



Figure 2. *Neckera crispa*, a large, pleurocarpous moss of tree trunks that has been used as a mordant in pottery. Photo by Michael Lüth.



Figure 3. A piece of ancient pottery with the impression of *Neckera crispa* that has been used as a mordant. Photo courtesy of Heinjo During of Universiteit Utrecht and Wim Kuijper from Archeological Centre of Leiden University.

In fact, mosses seem to be useful in maintaining structural integrity of a variety of materials. Siberian Eskimos roll up skins and freeze them into the shape of a sled runner, which they cover with a moss/water mix to protect the skins, smoothing them as they shape them onto the runners (R. Seppelt, pers. comm., based on "Man on the Rim" documentary).

In India, mosses are used for door covers and smoke filters (Pant 1989) and the pharki – a door mat (Glime & Saxena 1991). In Sweden, *Polytrichum commune* has likewise been used as a doormat (Hedenäs 1991). Their use as kindling is surely still valuable to campers (Thomas & Jackson 1985).

In some places, the past mixes in strange ways with the present. Among the Inuit at Pangnirtung in the Canadian North, electrical lines run to summer tents to power electric guitars while the tent is heated by ancient kudliks that burn with a wick of moss (Crowe 1974). A number of mosses make ideal lamp wicks: *Dicranum elongatum* (Figure 4)

by the Cree Indians, *Racomitrium lanuginosum* by



Figure 4. *Dicranum elongatum*, a moss used as a wick by the Cree Indians. Photo by Michael Lüth.

Padding and Absorption

The absorbent properties and abundance of *Sphagnum* make it the most used taxon among the bryophytes (Densmore 1928). The Chippewa Indians in North America used it as an absorbent. It serves as an insulator, as pillow, mattress, and furniture stuffing, to keep milk warm or cool, to stuff into foot mats for cleaning shoes, to weave welcome mats, and in Lapland to line baby cradles, keeping the infant clean, dry, and warm (Stark 1860). In the North Central States, USA, the Ojibwe Indians have used dried *Sphagnum dusenii* to make mattresses (Smith 1932).

The Potawatomi Indians in North America used *Sphagnum* species as fibers for rugs, mats, and bedding (Smith 1933). In parts of the Malay Peninsula, *Leucobryum* is used together with *Campylopus* (Figure 5) to stuff cushions and mattresses (B. C. Tan, pers. comm.).



Figure 5. *Campylopus introflexus*, a genus that has been used to stuff pillows. Photo by Michael Lüth.

In Germany, *Sphagnum* has been used in hospitals as neck and head rests, to support hips and backs, and to elevate the legs of wounded people (Hotson 1921). On the farm it is particularly good for absorbing urine from livestock and pets, a function shared with *Hylocomium splendens*, absorbing up to 55%, *Rhytidiadelphus*

squarrosus 33%, and *Pseudoscleropodium purum* 6%. And even the Romans used it for toilet paper (Birks 1982)! In the laboratory *Sphagnum* prevents red-leg in frogs, in part by absorbing the urine. In the Philippines, the crocodile breeding station uses peat moss as a cushion or layering material for incubation of eggs (B. C. Tan, pers. comm.).

Table 1. Comparison of weight gain measured as wet weight to dry weight ratio of selected bryophytes (Horikawa 1952).

<i>Atrichum</i>	6.9
<i>Barbula</i>	8.3
<i>Bazzania pompeana</i>	4.0
<i>Haplomitrium mnioides</i>	12.0
<i>Hylocomium cavifolium</i>	9.8
<i>Plagiomnium maximoviczii</i>	6.7
<i>Rhodobryum</i>	10.0
<i>Sphagnum</i>	12.4
<i>Trachycystis microphylla</i>	3.2

But *Sphagnum* is not the only moss with endearing, and enduring, qualities. Durability and elasticity may have contributed to the Japanese use of *Hypnum* to stuff balls and dolls (Pant & Tewari 1990). Others have used them for stuffing upholstery and hassocks (Thomas & Jackson 1985).

In the Azores, *Thuidium tamariscinum*, *Pseudoscleropodium purum*, and *Hypnum cupressiforme* were used to stuff pillows and mattresses (Allorge 1937). In fact, *Hypnum* was so popular as a pillow stuffing that Dillenius (1741) chose *Hypnum* as its name because of its association with sleep. And Linnaeus copied the bears, choosing *Polytrichum commune* for bedding (Crum 1973), stating that if a quilt could be made of it, nothing could be more comfortable (Black 1979). Both humans and domestic animals have enjoyed the comfort of a moss bed, with the absorptive ability serving an additional function for the animals (Ando & Matsuo 1984). And for all, mosses such as *Brachythecium*, *Dicranum*, *Hypnum*, *Neckera*, *Papillaria* (Figure 6), and *Thuidium*, add the advantages of being insect-repellent and resistant to mold (Pant & Tewari 1989).



Figure 6. *Papillaria nigrescens*, a suitable moss for packing fragile objects or making a bed. Photo by Michael Lüth.

Cleaning

The absorptive property, and often crunchy texture when dry, makes mosses useful for cleaning pots when

camping (Gould, pers. comm.), while the remaining mosses can be used to keep the fishing worms alive. In India villagers use mosses mixed with burned ashes to clean household utensils (Pant 1989).

Polytrichum, with its long, stiff stems, makes good brooms for dusting curtains and carpets (Crum 1973) and apparently *P. commune* is still in use for brushes in southern Sweden today (Hedenäs 1991). Stems are stripped of their leaves to make a broom 30-45 cm long (Thieret 1954).

Toiletries

I have learned from Susana Rams Sánchez that mosses are sold, mixed with a variety of other plant items (Figure 7), and sold for washing one's hair. I have to wonder what their role is – antibiotic perhaps? Other items in the mix include fresh flowers, presumably for their sweet odors.



Figure 7. **Upper:** Market place in Azrou, Morocco, where bags of herbs comprise the ingredients for washing hair. **Lower:** Bag of herbs mixed and ready for sale for washing hair. Photos by Susana Rams Sánchez.

Dillenius (in Crum 1973) stated that ladies of his time used an oil extract of *Polytrichum* for their hair, applying the Doctrine of Signatures because of the hairs on the calyptra.

One use that will probably remain forever among field personnel is that of toilet "paper" (Open-Air). *Sphagnum* is particularly suitable, both for its absorptive properties and its antibiotic properties.

Pesticides

We have known about the ability of bryophytes to discourage insect pests for centuries. Whereas tracheophyte herbaria require ill-smelling moth balls to protect them from destruction by tiny beetles, bryophytes store safely with no such protection. Such safety suggests that bryophytes may contain some sort of natural pesticide (Yepsen 1984), or simply be unpalatable. In nature, it is not unusual for capsules to be grazed by slugs – not a common organism in a dry herbarium, but the leafy portion of the same plant is often ignored.

Davidson and coworkers (1989) isolated the antifeedants ferulic and possibly m- or p-coumaric acid from a wall-bound fraction of the leafy shoots of *Brachythecium rutabulum* and *Mnium hornum* (Figure 8), parts ignored by slugs that readily grazed the capsules. Asakawa has devoted his life to finding a wide variety of phenolic and other ill-tasting or lethal compounds in liverworts. For example, the liverwort *Plagiochila* contains the sesquiterpene hemiacetyl plagiochiline A (Asakawa et al. 1980b) that inhibits the feeding of an African army worm (Asakawa et al. 1980a) and is an extremely potent poison to mice (Matsuo et al. 1983, unpublished data).



Figure 8. **Upper:** *Brachythecium rutabulum*, a large pleurocarpous moss. **Lower:** *Mnium hornum*. Both species are endowed with antifeedants such as ferulic acid. Photos by Michael Lüth.

Clearly not all bryophytes are so inhospitable to hungry herbivores. We have found that pillbugs (*Porcellio* spp.) will readily consume *Polytrichum juniperinum* leaves and *Thuidium delicatulum* plants while preferring starvation or paper towels to *Polytrichum* stems, *Dicranum polysetum*, or *Pleurozium schreberi*. L. Russell found that

one insect readily devours *Porella navicularis* until it eats a species of *Porella* that has a peppery taste (D. H. Wagner, pers. comm.). After eating the peppery species for a few minutes, it stops eating it and henceforth refuses to eat either *Porella* species. (How is it these creatures are such good taxonomists!?)

It appears that exploration of antiherbivory compounds in bryophytes could prove quite profitable. But I must ask, if insects don't eat them, what is the reason? Doesn't that mean that the ones that ate them didn't pass on their genes? And do I really want the lethal products of those bryophyte genes in **my** food? Certainly a long regime of testing stands between us and widespread use for this purpose.

Fortunately, so far moss genes are only being considered for a commercial level of transplantation into tobacco (Comis 1992) – a step that has already been accomplished. Oliver and colleagues, working at the United States Department of Agriculture in Lubbock, Texas, have isolated (Scott & Oliver 1994) and transplanted (Oliver et al. 2000) several genes from *Syntrichia* (*Tortula*; Figure 9) that are specific for recovery from desiccation. Antiherbivory genes are being considered as well. But will tracheophytes be able to express these genes in meaningful ways?



Figure 9. *Syntrichia ruralis*, a moss being studied for possible transfer of genes for drought tolerance and antiherbivory into tobacco. Photo by Michael Lüth.

Clothing

Can you imagine wearing mosses? In some parts of Germany, wool was woven with *Sphagnum* to make a good, cheap cloth (Hotson 1921), whereas in Mexico, the dark-colored extract of a rock-inhabiting moss is used to color it (Delgadillo, pers. comm.).

In the Philippines, the tall moss *Spiridens reinwardtii* is used by some of the natives to decorate head gear and clothing (B. C. Tan, pers. comm.).

Several cultures have used *Sphagnum* (Bland 1971; Carrier Linguistic Committee 1973; Turner 1983; Compton 1993; Smith 1997; Moerman 1998; Marles et al. 2000) and *Dicranum scoparium* (Figure 10) for lining diapers, and even modern diapers from Johnson & Johnson in the U.S. and Canada can have *Sphagnum* liners (Johnson Gottesfeld & Vitt 1996). Alaskan Native Peoples have used blades of grass, rubbed together until soft, mixed with peat moss and squirrels' nests to line a cradle as a diaper (Kari 1985).

Michigan's Chippewa Indians used *Sphagnum* for this purpose to keep the babies clean and warm (Crum 1973). In fact, Johnson Gottesfeld and Vitt (1996) learned that certain species were preferred and some avoided by the indigenous people. The long, pink (not red) plants of *Sphagnum magellanicum* were preferred, but short, yellow-green, and red plants were considered unsuitable. Red *Sphagnum nemoreum* (Figure 11) caused irritation.

The New Zealand Maori have used *Lembophyllum clandestinum* for diapers as well as for baby bedding (Cooper & Cambie 1991) – just think, a dual purpose moss! *Sphagnum* is even used today in mattress pads for infants (Turner 1993). In California, there is no *Lembophyllum*, but *Alsia* served the Native Americans for baby bedding (Thieret 1956).



Figure 10. *Dicranum scoparium*, a moss used by several Canadian cultures for diapers. Photo by Michael Lüth.



Figure 11. *Sphagnum (capillifolium) nemoreum* illustrating the red colors that seem to be associated with diaper rash when used for baby diapers. Photo by Jan-Peter Frahm.

In Germany and Nordic countries, *Sphagnum* has become popular to line hiking boots (Figure 12; Hedenäs 1991), not only cushioning the feet, but absorbing moisture and odors while discouraging bacteria. Thanks to Gillis Een, I have been enjoying the boot liners and can attest to their comfort.

Natives of the Philippines use mosses to decorate headwear and clothing (B. Tan, pers. comm.). In New Guinea, *Dawsonia grandis* is worn by natives in bracelets and hair (Van Zanten 1973) and to decorate ceremonial masks (Richardson 1981). The British in England used the moss *Climacium dendroides* (Figure 13), artificially colored (Clarke 1902), to decorate a lady's hat (Tripp 1888). And in Boston, the early cultural center of the United States, braids of *Pseudoscleropodium purum* and cords of *Neckera crispa* and *Dicranum* decorated ladies'

hats and bonnets (Clarke 1902). In the villages of Kumaun, India, women stuff such mosses as *Hylocomium*, *Hypnum*, and *Trachypodopsis* into cloth sacks to make the *sirona*, a head cushion, that both cushions the vessel and absorbs water that splashes from it (Pant & Tewari 1989).



Figure 12. Advertisement for shoe lining made from *Sphagnum*. Photo by Janice Glime.



Figure 13. *Climacium dendroides*, a moss dyed and used to decorate ladies' hats in Great Britain. Photo by Michael Lüth.

The large size of *Dawsonia grandis* affords it more utility than most mosses. In New Guinea, it is stripped of its leaves, dried over a glowing fire, stripped of its outer layers, split in two, then plaited into a red rope to decorate net bags and other objects (Van Zanten 1973). In New Zealand, it was other members of the Polytrichaceae that proved useful. The shoots and leaves of *Polytrichum commune* and *Polytrichadelphus magellanicus* were used in making Maori cloaks, with alternating brown and black serving as decoration (Beever & Gresson 1995). The numerous air spaces, serving the moss for capillary movement and water retention, most likely provided an insulating warmth to the wearer.

Even buttons can be made from bryophytes (Figure 14). In Europe, peat is pressed into disks and a design stamped into it to make an attractive button for clothing.



Figure 14. Button made of pressed peat. Photo by Janice Glime.

Archaeological evidence tells us that soft mosses such as *Hylocomium brevirostre* were used to pad Mesolithic flint blades, protecting the user's hand (Dickson 1973; Figure 15).

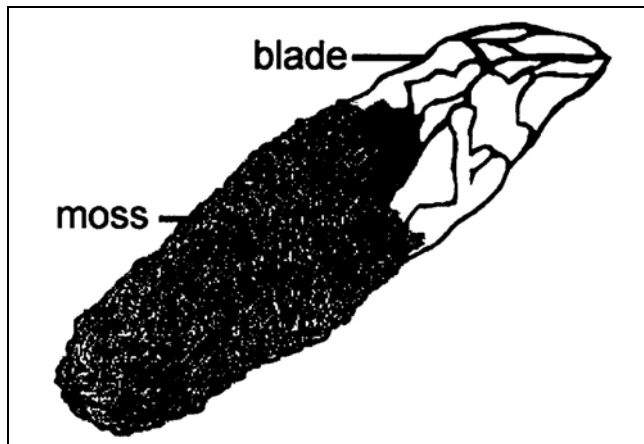


Figure 15. Mesolithic knife handles in Europe were sometimes wrapped with moss. Drawing based on photograph by Dickson (1981).

Food Source

If even the insects won't eat the bryophytes, it is no wonder that they seldom have been used for human food. The Chinese consider mosses to be a famine food (Bland 1971). Their low caloric value (Forman 1968) and often abominable taste are efficient deterrents to herbivores of all sizes. Mizutani (1961) complained that it was necessary to gargle to get rid of the bitter liverwort taste, no doubt a result of the numerous phenolic compounds in a single species. Thus it is not surprising that the only country where any bryophyte seems to be a significant component of food is in the peat-rich Lapland where *Sphagnum* was once used as an ingredient in bread (Bland 1971). Native Americans used *Camassia quamash*, simmered in blood with moss, to make a soup (Hart 1992).

A lot of drinks, especially teas, are made from a variety of odd plant substances with antibiotic properties.

Some Native Americans have used *Sphagnum* leaves to make tea (Carrier Linguistic Committee 1973).

One historic note is that in the second edition of the Dictionary of Dates (Joseph Haydn, London, 1854), Peter, the Wild Boy, is described (C. R. Stevenson, Bryonet 27 November 2006). Peter was a savage creature who lived in the forest of Hertswold, electorate of Hanover, Great Britain. Peter walked on his hands and feet, climbed trees like a squirrel, and was found eating grass and moss in November of 1725. But even this recorded history of human consumption is in question because moss has many meanings to a lay person, and we cannot be sure it was truly a bryophyte being described.

Vitamins

Although bryophytes do not seem to be good candidates for food, some bryophytes may provide specific needs for animals both in the wild and on farms. For example, *Barbella pendula* has a high content of vitamin B₁₂ and causes no noticeable side effects when fed to puppies and chickens (Sugawa 1960). *Sphagnum*, as milled peat, provides a binder for iron and vitamins used to supplement the diet of anemic piglets.

Masanobu Higuchi (Bryonet 20 November 2006) reports being served a soup in southwestern Yunnan, China, ordered by his friend. He found something tough and hard to chew in the soup. On close examination, he identified it to be the moss *Rhodobryum giganteum* (Figure 16). He speculated that the chef may be including it as a medicinal herb.



Figure 16. *Rhodobryum giganteum*, a medicinal herb and soup ingredient in China. Photo by David Long.

Flavoring

Mosses have, however, been used for flavoring, though not commonly. *Sphagnum* contributes to the flavor of Scotch whisky. First, the grains are steeped in water from a *Sphagnum* peatland during the malting stage. This mix is then steeped over a peat and coke fire in kilns, with the fire under the screens that hold the barley malt sprouts, and this pungent flavor persists through the subsequent distillation process (Miller 1981). In a drink of wine, *Marchantia polymorpha* soaks up the wine and makes a tasty, crunchy treat with your drink. Hmm...are our favorite organisms only consumed with alcohol?

Vassilios Sarafis (Bryonet, 19 November 2006) reports having tried capsules of *Polytrichum commune*, finding them tasty. Amanda Hardman (Bryonet, 19 November

2006) claims to fancy the *Funaria hygrometrica* capsules, but states that you must catch them at just the right ripeness. To her, they can taste "as good as yummy sweet peas." Nevertheless, Rod Seppelt (Bryonet, 19 November 2006) compares preparing bryophytes as a food to that of the recommended way to cook a Galah (otherwise known as a Rose-breasted cockatoo) in Australia. You put a stone and water in the pot with the Galah, bring to a boil, and when the stone is soft, throw away the Galah and eat the stone! In the case of bryophytes, it is the phenolic compounds that make them unpalatable and of questionable safety for consumption.

There have certainly been experimental uses of mosses for food flavoring. Stefan Rensing (Bryonet, 21 November 2006) reports that a group of ~50 botanists at a party sampled a newly created drink called "Psycho Physco." This drink contained a teaspoonful of protonemata from a bioreactor liquid culture of the prominent research moss *Physcomitrella patens* (Figure 17). Rensing reports that the taste was "quite interesting (not unpleasant)" and all 50 persons survived unharmed.



Figure 17. *Physcomitrella patens*, the lab rat of bryophytes for which the protonema was tested for "taste" in a drink by a group of European botanists. Photo by Michael Lüth.

A well-known chef in Europe is looking for bryophytes to flavor his dishes, giving them a unique taste (Marta Infante & Patxi Heras, Bryonet, 18 November 2006). He plans to enter them in a gastronomical contest. So far he has tried *Pseudoscleropodium purum* (Figure 18) in tempura and made an infusion with *Boletus edulis*. But there are concerns about possible side effects and bryophytes to avoid.



Figure 18. *Pseudoscleropodium purum*, a large moss being explored for taste contributions to food and still being used in shipping plants and fragile objects. Photo by Michael Lüth.

Chinese Gallnuts

Perhaps the most important use of mosses in the food industry is indirect. Several mosses, especially species of *Plagiomnium* (Figure 22), are winter hosts to the Chinese gallnut aphid (*Schlechtendalia chinensis*), the insect that provides those gallnuts that are both a delicacy and important medicine in China (Horikawa 1947; Wu 1982; Ando 1983). The gallnuts, formed on the leaves of *Rhus javanica* (), are used as pain killers, antiseptic and antidiarrheal agents, and as expectorants, astringents and preservatives (Min & Longton 1993), and in industry as a source of tannic acid.

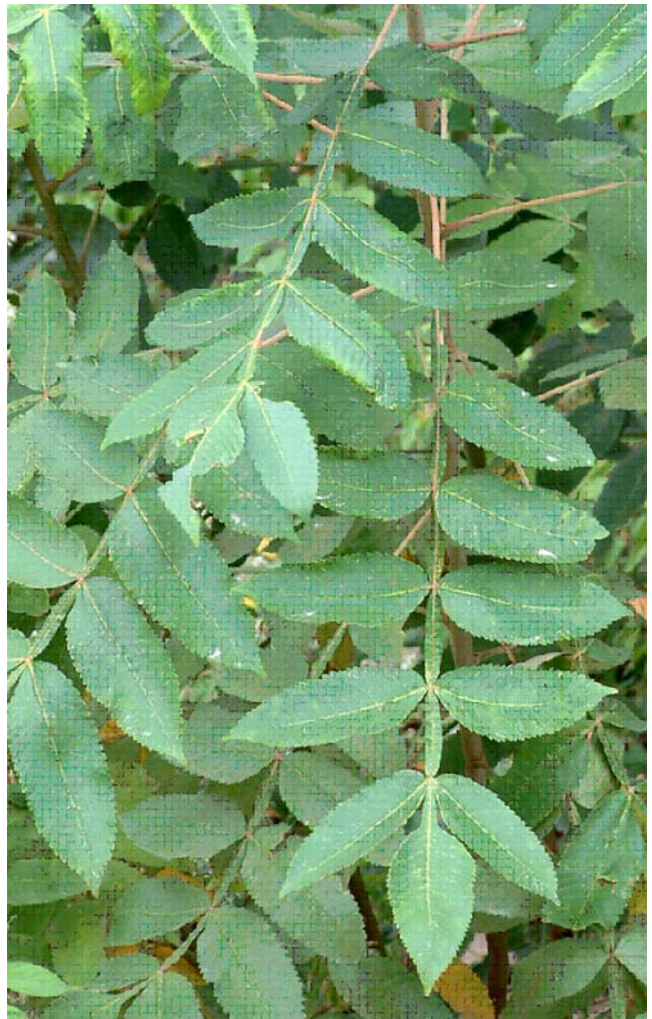


Figure 19. Leaves of the summer gallnut host, *Rhus javanica*. These plants must be near suitable mosses for the gallnut aphid to survive the winter. Photo by Yingdi Liu.

The gallnuts were so important that Takagi (1937) proposed the culture of suitable mosses in order to increase gallnut production. In China, the aphids are now reared agriculturally on mosses (Tang 1976). In Yunnan the host tree and the most common host mosses (species of *Plagiomnium*) do not have large overlapping distributions, making establishment of the gall aphids difficult. The aphids lay their eggs on the moss and the young larvae survive during winter using the moss as food. In some areas, mosses are reared in bowls that are placed under the trees for several weeks during autumn until the aphids locate them (Min & Longton 1993). Then the bowls are

moved into sheds for the winter. In April the moss is removed from the bowls and placed back under the trees. The bowls are supplied with fresh soil and kept in a more suitable place where the remaining moss fragments regenerate. By October these mosses are sufficiently large to use the same bowls to gather the next winter's crop of aphids.



Figure 20. These gallnuts of the aphid *Schlectendalia chinensis* occur on the branch of the sumac, *Rhus javanica*. Photo by Yingdi Liu.



Figure 21. These harvested gallnuts are used for eating and medicinal purposes in China. Photo by Yingdi Liu.



Figure 22. *Plagiommium undulatum*, one of the overwintering hosts mosses for the Chinese gallnut aphid. Photo by Michael Lüth.

Food Improvement

There seems to be little interest in cultivating bryophytes themselves for agricultural purposes. However, they do contribute peripherally to our food. They are used as a carrying medium for the nitrogen-fixing *Rhizobium* inoculants for legume production (Turner 1993). And currently there is research to try to encourage the Cyanobacterium *Nostoc* to grow on roots and stems of plants. This photosynthetic bacterium, once known as a blue-green alga, is able to convert atmospheric nitrogen into ammonia, making it usable for plants. But what has this to do with bryophytes? Well, there has to be a source of the *Nostoc*, and this should be a species adapted to living in association with a plant. A number of liverwort taxa are known for Cyanobacterial partners. In this case, it is *Anthoceros* (Figure 23) that has contributed the *Nostoc*, which Gantar and coworkers (1995) are trying to persuade to live and fix nitrogen on, of all things, wheat roots! That would go a long way toward solving fertilizer problems! And Rao and Burns (1990a, b) have suggested the use of *Anthoceros* as a living agricultural fertilizer because of its *Nostoc* partners. That might even work, since *Anthoceros* likes disturbed areas.

Use of peat mosses for culturing certain foods is common. One environmentally friendly use is the combination of extracts from fisheries by-products with peat compost (Martin 1992). This is especially true in coastal areas where the more usual by-products are limited in availability. Products of this fermentation process can be used successfully to feed, of all things, more fish! Then there are the agricultural uses – growing mushrooms, salad greens, and other specialty crops (Turner 1993) that will be discussed in the sub-chapter on commercial uses.



Figure 23. *Anthoceros agrestis*, a hornwort with Cyanobacterial partners that fix atmospheric nitrogen. Photo by Michael Lüth.

Peat water is typically brown and looks unfit to drink, but for sailors going on a long journey, it has provided a safer alternative (Dente 1997). It would stay free of algae longer than well or spring water.

Cookery

The pendant *Antitrichia curtispindula* was used by Native Americans in earthen ovens for cooking (Compton 1993).

Food Preservation

In Alaska, a switch from traditional methods of preparing foods is causing an increase in botulism, more than 12-fold since 1966 (Segal 1992). These natives clean and process their foods outdoors on the ground, then place them in a shaded pit lined with wood, leaves, or animal skins. Before they adopted modern technology, they covered this food with mosses. Now they use plastic, maintaining a humid and anaerobic environment that promotes the growth of *Clostridium botulinum*. The natives do not trust the advice of outsiders, so the Health Department feels the best plan to reduce the spread of the disease is to encourage them to return to their traditional use of mosses. The mosses permit aeration and may even have antibiotic effects.

Packing

One wouldn't expect a plant that harbors a wide range of insects to be a suitable insect repellent, but the Himalayans dried mosses, made them into a coarse powder, and sprinkled them over grains and other containerized goods to repel insects (Pant & Tewari 1989). They covered the top of the container with a plug of mosses. When they were ready to use the grain, they simply blew off the lightweight mosses from the grain. Just consider the safety of this natural way of repelling the insects while protecting the human consumer. In the Pacific Northwest, mosses are collected to pack mushrooms and keep them safe (Cleavitt 1996).

Modern methods of packing food have actually increased the incidence of botulism among Alaska natives (Segal 1992). Traditionally, the natives processed fish and sea mammals on the ground where they easily made contact with bacteria from the soil or animal viscera. The food was placed in a shallow pit lined with wood, animal skins, or leaves. These buried animals were then covered with moss or leaves and left to ferment for one or two months. However, the natives switched to modern technology and used plastic bags to line the pits and enclose the food, eliminating the use of moss and other plant matter. The anaerobic conditions created by this method promoted the growth of *Clostridium botulinum*, permitting the production of the botulism toxin. Public Health Officials determined that the safest approach was to encourage the natives to return to their traditional methods.

Taxidermy usually requires the use of arsenic to keep hungry beetles from consuming our treasures. But at the British Museum, it was mosses that served this role. Curators stuff the skins with mosses to ward off the dermestid beetles and at the same time keep the skins plump and natural (Harrington 1985).

Packing materials vary with what is available locally and can even be used to determine the region and habitat of origin. In the western US, epiphytic mosses such as *Antitrichia californica*, *Dendroalsia abietina*, and *Neckera menziesii* provided suitable packing material for vegetables, helping to retain moisture (Grout 1902; Frye 1920), whereas today similar species are used to pack mushrooms (C. W. Smith, pers. comm.). The Himalayans still use both soil and epiphytic mosses such as *Brachythecium salebrosum*, *Cryptoleptodon flexuosus*, *Hypnum cupressiforme*, *Macrothamnium submacrocarpum*, *Neckera crenulata*, *Trachypodopsis crispatula*, *Thuidium*

tamariscellum, and *Sphagnum* to pack apples and plums (Pant & Tewari 1989). But in the tropics, it is the leafy liverworts that play this role because of their abundance (Bland 1971). Large and abundant mosses like *Pseudoscleropodium purum* (Dickson 1967; Figure 24), *Hylocomium splendens*, and *Rhytidiadelphus squarrosus* have been dispersed around the world due to their widespread use as packing materials (Seaward & Williams 1976). Allen and Crosby (1987) refer to these worldwide expansions of *Pseudoscleropodium purum* as legendary – even today, it is used for packing young trees destined for Tristan da Cunha, where its establishment is imminent. It seems to have arrived on the West Coast of North America by the late 1800's (Miller & Trigoboff 2001).



Figure 24. *Pseudoscleropodium purum*, a moss commonly used in packing. Photo by Michael Lüth.

Large mosses make good cushions for fragile objects. In Japan, boxes packed with large pendant mosses such as *Aerobryopsis subdivergens*, *Barbella deterrisii*, and *Meteorium helmintoctadulum* (e.g. Figure 25) guarded ancient silk clothes, providing a clean and soft packing (Noguchi 1952). Where dirty soil was of less concern, soil mosses such as *Rhytidiadelphus triquetrus* protected fragile China (Dickson 1973), and Espie (1997) claims it is "most valuable for packing material for porcelain" in New Zealand. Other mosses are used for packing fragile items in the Philippines (B. C. Tan, pers. comm.). *Hypnum*, *Plagiomnium undulatum*, and *Sphagnum* guarded the blades of daggers and scrapers (Dickson 1967). Even the Department of Defense used mosses (*Sphagnum*) to pack fragile bomb sights during World War II (K. Parejko, pers. comm.).



Figure 25. *Meteorium illecebrum*, a large moss such as those used for packing fragile articles. Picture by Michael Lüth.

The Open-Air Natural History Museum states that *Sphagnum* is good for winter storage of carrots to keep them fresh (Open-Air).

The antibiotic properties of *Sphagnum* make it ideal for shipping small amphibians such as salamanders and frogs from biological supply houses (Figure 26). It keeps the animals moist and helps prevent diseases like red leg by absorbing the urine and reducing bacterial growth.

In New Zealand, where *Sphagnum* has never been common, new commercial uses are surfacing (SFF Project Summary 2006). In a project titled "Economically sustainable novel *Sphagnum* moss products," three new commercial uses are proposed. These include packaging due to the absorbent and antibiotic properties that would reduce fruit spoilage. They likewise suggest using it for animals, but on the larger scale of veterinarian services, reducing odors and providing absorption. Their third suggestion, already done in several large wars, is to use the moss for bandages, especially those that are particularly "weepy" and thus more prone to infection. In their early experiments, however, they failed to show that *Sphagnum* protects apricots or avocados from post-harvest infections. They are currently looking for a sponsor to research the effects of using *Sphagnum* bandages of burn victims.



Figure 26. *Rana pipiens*, protected from red leg by the *Sphagnum* substrate in the terrarium. Photo by Janice Glime.

Summary

Mosses are used for carrying water, stuffing mattresses, pillows, and dolls, collecting urine from farm animals, cushioning fruits, and packing fragile articles. They even provide vitamin supplements to animal feed. In northern areas they are used for heating, making wicks, and in Morocco they are used to wash hair.

Recently, one of the more important uses is for physiological studies and genetic studies linking genes to processes. This investigation is leading to the possibility of transplanting genes for traits like drought tolerance and antiherbivory into agricultural plants.

Despite the unpleasant taste of most bryophytes, *Sphagnum* has been used in Scotch whisky, *Marchantia polymorpha* has been added to wine, and one European chef is experimenting with new recipes using bryophytes. Capsules may be more tasty if collected at the right stage. Some mosses serve indirectly by

providing the overwintering home for gall aphids. The galls made by these insects are used for food and medicine. More commonly, mosses are used for culturing a variety of food plants.

The soft and flexible texture of mosses makes them ideal for packing a variety of items, leading to the spread of some species around the world.

Mosses have been used for making and decorating clothing and pressed buttons. Most importantly, they have been used for diapers and other absorbent roles like lining boots.

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