Phyton (Horn, Austria)	**Vol. 46**	Fasc. 2	215–217	11. 6. 2007

Green Roofs - Pollination Ecological Islands in the City

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Due to the ability of green roofs to compensate extreme temperatures, they were used traditionally in cold as well as in hot regions to improve climate within buildings. Examples herefore are the grass sod houses in northern Iceland, the traditional grass-grown houses in Norway and Sweden, the Kota in northern Sweden, and the Hehe house in Tansania (STIFTER 1988). Since the end of last century, the amount of green roofs in Central Europe is steadily increasing because of the growing awareness of the various advantages of roof greening. A very famous contemporary example is the Hundertwasser house in Vienna, Austria.

So, why do we want to grow plants on roofs and undertake such an effort? Green roofs have a distinct ecological and economical significance for urban areas (DREFAHL 1995, DÜRR 1995, KOLB & SCHWARZ 1999, KRUPKA 1992). Green roofs reduce and retain the runoff of rain water, improve the temperature climate of buildings, produce oxygen, absorb dust and noise, physically protect the roof from heat and UV-radiation, and finally, a living green surrounding improves wellness and health of people.

Before starting to green a roof, the static of the building has to be consulted, in order to know the maximum load the roof can bare. This is a prerequisite to decide on the type of vegetation that can be planted. Construction details are given in GRÜTZMACHER 1993, KLEINOD 2000, KOLB & SCHWARZ 1999, KRUPKA 1992, and STIFTER 1988. A substrate layer of 5–15 cm thickness enables an extensive greening of roofs. A careful selection of plants minimizes the risk of total loss during extreme climate periods. Primarily natural or nature-like plant communities (bryophytes, succulents, grasses, herbs) should be planted. A completely water saturated bryophyte-*Sedum*-vegetation on 2–6 cm of substrate will weight only between 30 and 90 kg/m^2. Non-succulent herbs require at least 6–10 cm of

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substrate. Then, the load will sum up to 60 to 140 kg/m^2. Compared to that, a 5 cm layer of pebbles that are frequently used to protect flat roofs against UV-radiation and overheating weighs 80–90 kg/m^2 when completely wet (KÖHLER 1993, KOLB & SCHWARZ 1999, STIFTER 1988). A simple intensive greening of roofs can be realized on 15–25 cm thickness of substrate, which allows nature-like plant communities and gardening cultures (perennials, grasses, small schrubs and bushes). Gardening cultures similar to those on natural soil (perennials, bushes and small trees, vegetables and fruits) need at least 25 cm of substrate (intensive greening of roofs).

The focus in this contribution lies on extensive greening of flat roofs because they are easiest to realize and offer good opportunities to create nature-like habitats for a variety of plants and animals. Several criteria to select plants for extensive greening have to be considered. Local species should have priority. They are better adapted to climate and local fauna. In many cases specially adapted subspecies or races can be used. Species richness and the variety of ecological niches can be increased by varying the substrate thickness and type of substrate. Plants suitable for roof greenings can be found in various habitats, frequently in urban areas and anthropogenically influenced sites. Primary settlement of bryophytes and lichens and following succession of higher plants can be found on old roofs and walls. Furthermore, many species of dry meadows, rocky ridges, dunes, sandy fallows, gravel pits, and wall copings (Sedo-Scleranthetea and Festuco-Brometea) have been successfully cultivated on roofs (KRUPKA 1992).

Further criteria to select plants are their interactions with animals. Many species that grow on roofs with extensive greening offer nectar or pollen for butterflies, bees, beetles, flies, and bumble bees: *Allium* ssp., *Aster amellus, Centaurea scabiosa, Coronilla varia, Dianthus carthusianorum, Origanum vulgaris, Petrorhagia saxifraga, Prunella grandiflora, Silene vulgaris, Veronica teucrium*, and many more. Other species are important food sources for caterpillars (KOCH 1991), e.g. *Sedum album* for Parnassius apollo (Papilionidae), many *Poaceae* species for Satyridae species, *Euphorbia cyparissias* for Celerio euphorbiae (Sphingidae), *Galium verum* for Celerio galii and Macroglossum stellatarum (both Sphingidae), and *Ononis* species for Lycaena icarus (Lycaenidae). Further studies are needed, e.g. to record the occurrence of animals on green roofs, to elaborate the minimum area of green roofs within cities that are necessary to establish and maintain stable pollinator populations, or to study the genetic exchange with rural populations.

An analysis of most frequent literature (KLEINOD 2000, KÖHLER 1993, KOLB & SCHWARZ 1999, KRUPKA 1992, STIFTER 1988) shows that about 250 species have been successfully used for extensive greening of flat roofs.

Among those, 160 species are occurring naturally in Central Europe, and 19% of those are on the list of endangered species („Rote Liste") in Germany. Green roofs therefore provide refuge for endangered plant species and plant associations. Moreover, many endangered pollinators could find new habitats on roofs, an underestimated aspect so far.

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