LifeMedGreenRoof Project
Plant Selection and Performance Report

LIFE12ENV/MT/000732

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All images were taken by Mr Vince Lloyd Morris unless otherwise credited.

Action C.1: Monitoring the impact of the Project actions – Monitoring of the Vegetation

Report on the Selection and Performance of Green Roof Plants at the LifemedGreenRoof Project at the University of Malta.

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Introduction

The benefits of green roofs are increasingly been recognised in many countries but predominantly those within the Northern Hemisphere. The green roof model utilised within the Northern Hemisphere generally consists of a relatively shallow substrate usually around 150mm which is planted predominantly with succulents such as Sedum sp. or grasses (Figure 1). Attempts to import this model into southern Mediterranean countries such as Malta have proved largely unsuccessful and as a result the existence of green roofs in the region is virtually set at zero.

Figure 1. The green, undulating roof of Espace Bienvenüe was designed by Pargade Architects for the Cité Descartes campus in Paris (http://www.archdaily.com/597901/espace-bienvenue-jean-philippe-pargade)

It was therefore apparent that a green roof technology specifically designed to suit the particular conditions was urgently required. It became recognised that there was a need for more research specifically aimed at the particular conditions experienced within the southern Mediterranean region. Researchers from the Building Environmental Research Group at the University of Athens in 2012 recognised that:

"*It is evident that future research and technical development is necessary in order to develop new and more efficient materials and procedures as well as new advanced demonstration and large scale application projects."* (Santamouris, 2012).

It was with this specific aim in mind that the LifeMedgreenRoof Project was established in 2013 at the Faculty for the Built Environment at the University of Malta. One of the early proposed aims or actions of the Project Proposals (Action A1) was the *"Setting up of Trials to test the adequacy of native and locally propagated plant material…… ."*.

Figure 2. Typical skyline view of Malta as seen from the LifeMedGreenRoof Laboratory Roof

As stated previously, the number of green roofs established in Malta is extremely low. One of the factors which has led to this lack of up-take is the misconception that the climate experienced is too harsh and therefore plants would not survive on roofs. Indeed, Malta does, in fact, experiences very hot, dry summers when temperatures during August and September often exceed 30°C. Figure 3 illustrates graphically this climate pattern.

Precipitation occurs during the winter months when isolated rain events can be very heavy and have led to serious flooding in many urban areas (Figure 4).

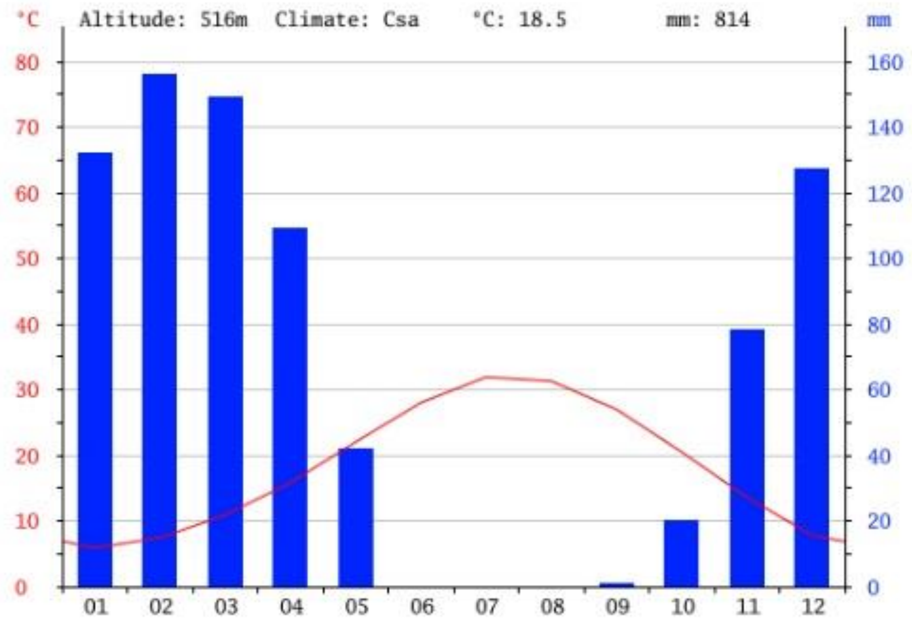


Figure 3. Annual average Precipitation and Temperature in Malta.

(https://en.wikipedia.org/wiki/Climate_of_Malta)

Figure 4. Heavy winter rains can cause severe flooding in many urban areas of Malta.

(www.timesofmalta.com/.../20160624)

Selection of Plants

In the open Maltese countryside, vegetation has adapted to cope with this harsh climate and many native plants exhibit xerophytic adaptions such as succulence, reduced leaf area, reflective or hirsute surfaces. As the countryside is exposed to high solar radiation during the summer months many plants appear to perish in that their areal parts desiccate and wilt. Some plants are annuals and survive via seeds. Others, generally perennials, have structures such as bulbs or swollen underground tubers which allow them to survive the harsh summers. Such plants are referred to as 'summer dormant' or as 'drought evaders'. However, the Maltese LifeMedGreenRoof Project has established that native, perennial plants can survive on roofs throughout the hot summer without becoming dormant if given the correct management and conditions.

Figure 5. Garique Landscape at Dingly Cliffs on the southern coast of Malta.

It has been shown that the survival of native, perennial plants depends on a number of factor which include:

- the selection suitable plants that are adapted to the prevailing climatic conditions.
- adequate irrigation levels
- sufficient substrate depth
- its water holding capacity.

The observations on plant survival recorded by the LifemedGreenRoof Project team at the University of Malta are corroborated by research carried out at the University of Melbourne in Australia. They found that plants exposed to drought conditions survived 12 days longer when planted in substrates with higher water holding capacity. As would be expected plants with lower water use or demand also survived 12 days longer than those with a higher water use. In conclusion they established that:

"To maximised survival, green roofs in year round or seasonal hot and dry climates should be planted with species that have high leaf succulence and low water use in substrates with high water holding capacity." (Farell, et al., 2012)

With the challenging environment experienced on Maltese roofs it was decided that probably the best habitat to search for potential plant species would be the Garique habitat of the islands. The Garique is characterised by shallow, infertile soils. They are also exposed to hot surface temperatures and are often located close to the coastline where they experience strong, salt laden winds. As such the vegetation type is described generally as open scrubland consisting of both annuals and perennials with low growing shrubs, aromatic herbs and grasses. The conditions found at the Garique suggested that the plant species found there would be likely candidates for surviving the conditions found on the roofs of Malta.

Figure 6. Plants from the Garique habitat showing adaptions to the harsh conditions experienced. [1] Crithmum maritimum [2] Sedum sediforme [3] Santolina chamaecyparissus [4] Hypericum aegyppticum

Many plants within the Garique plant community exhibit xerophytic adaptions such as reduced and/or silver coloured leaves (Hypericum aegyppticum and Santolina Chamaecyparissus) and succulence (Sedum sediforme) . Others a have adaptions that allow them to survive in high salt conditions and these are referred to as halophytes (Crithimum maritimum)

Around thirty species from the Garique ecosystem were selected and plants grown from cuttings. When sufficiently developed, the plants were transferred to the Test Trays. These Trays were constructed from sheets of 10mm thick, recycled plastic and measured 1000mm x 1000mmm x 250mm. Of the 20 Test Trays available half were filled with Planting Media A and half with Media B to a depth of 200mm. Both Planting media contained the same components but in slightly differing proportions (see Appendix B for details) However, one component, referred to in the horticultural industry as Biochar, was uniquely added to Planting Media B. Biochar is a soil amendment created by burning organic material in reduced oxygen conditions to produce a charcoal like material, a process known as pyrolysis (www.biochar-international.org/biochar). This soil enhancer can hold carbon, and has been shown to increase soil biodiversity and increase the water holding capacity of substrate. This later characteristic is obviously of value in coping with the dry conditions of a Maltese summer.

Non- Native Species

During the planning and planting of the Demonstration Green roof above the Faculty for the Built Environment at the University of Malta is was decided to introduce and number of non- native species to provide additional form, colour and interest to the planting scheme. These plants tended to come from parts of the world that had similar climatic conditions as Malta. They were also selected on the basis that they were well established in cultivation and had proved to be useful and non-invasive. Introduced species included: Dianthus deltoids, Salvia coccinea, Gazania rigens and Osteospermum sp. .

Figure 7. Trial plants propagated from cuttings and initially grown in plastic module

Figure 8. Test trays located on the roof of the Faculty for the Built Environment, University of Malta. Sixteen specimens of each species were selected with half being planted in media A and half in media B.

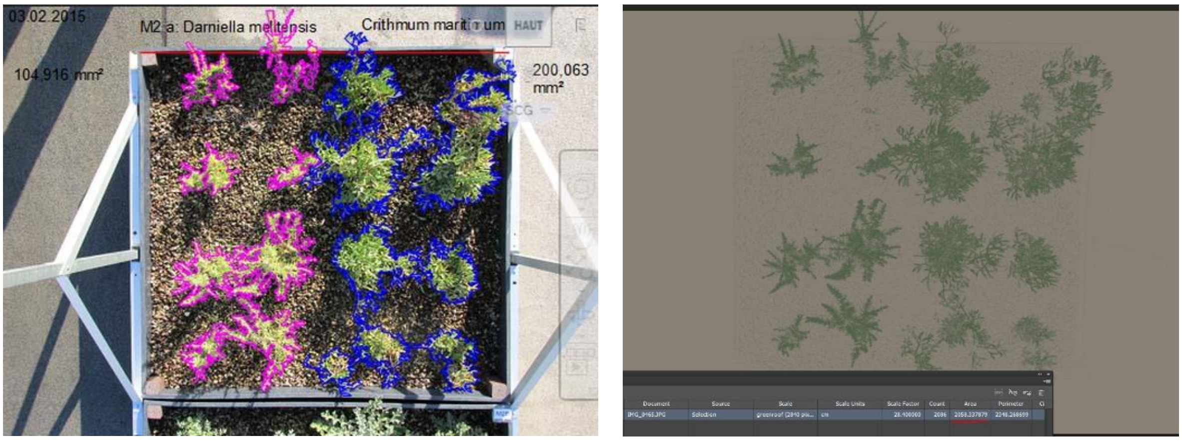
Collection of data on performance

Growth of each species was recorded photographically. An Aluminium 'jig' was constructed to hold a still camera at a constant height above the test trays. Photographs were taken at time intervals of two weeks.

Figure 9. Camera jig used to record photographically the performance of the selected plants

A subjective assessment of the performance of each species was undertaken by visually comparing the bi-monthly images. To gain a more objective and quantitative assessment it was decided to measure the leaf area of each individual plant at regular intervals. A search was made for suitable software that could identify the foliage, isolate it and provide a measurement of area but unfortunately none could be found initially. It was therefore decided to draw around the perimeter of each plant's foliage area in AutoCAD but this was found to be too time consuming. Later, Adobe Photoshop was used to isolate the area of plant growth and provide a measurement of area.

Figure 10. Methods of measuring plant growth via area of increase using AutoCAD on the left and Adobe Photoshop on the right.



Results and Observations.

Growth Performance

The growth performance of each of the plant species selected were represented in graphical form so that trends would be easier to visualise. Figure 11 below illustrates the growth pattern of two species Darnella melitensis and Crithmum maritimum which shows the typical trend exhibited by many of the plants selected. That is a steady increase in vegetation coverage throughout the spring with a rapid reduction following flowering and the production of seed.

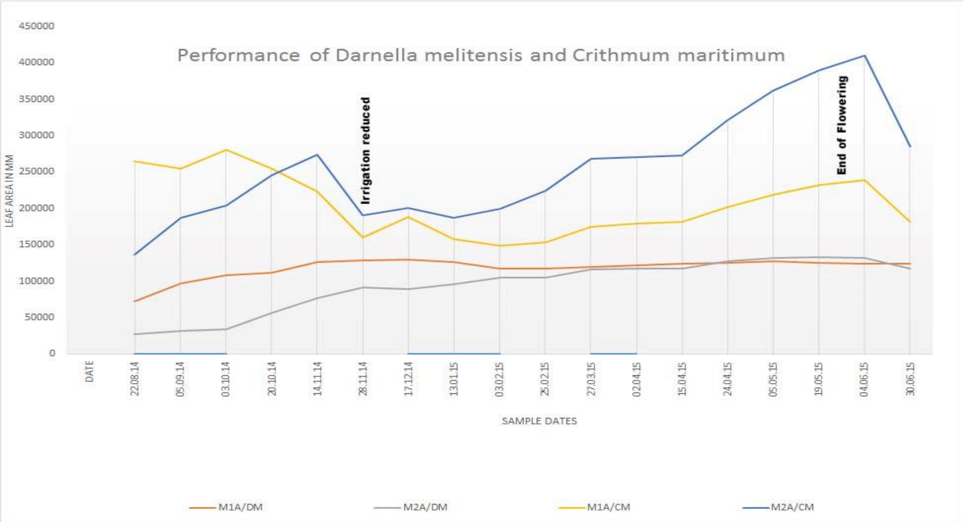
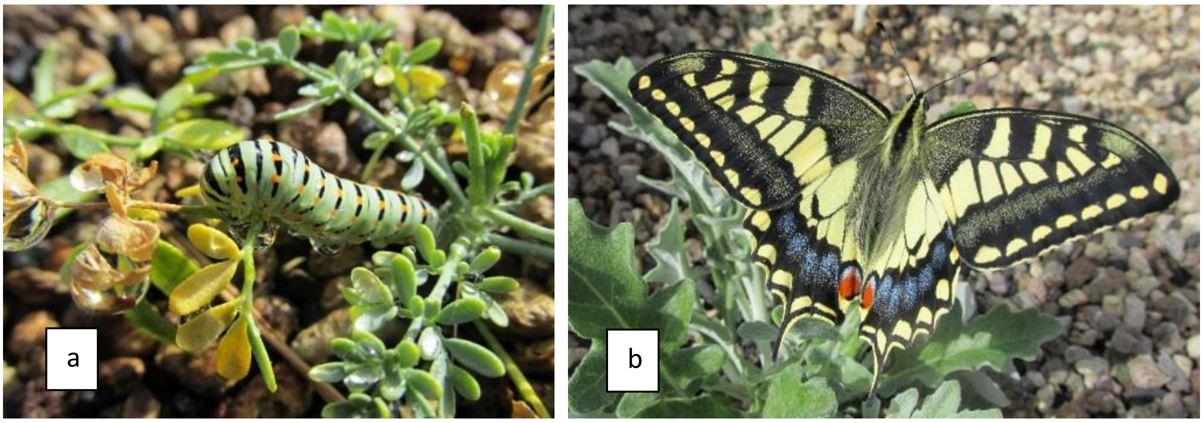


Figure 11. Graph showing growth of Darnella melitensis and Crithmum maritimum

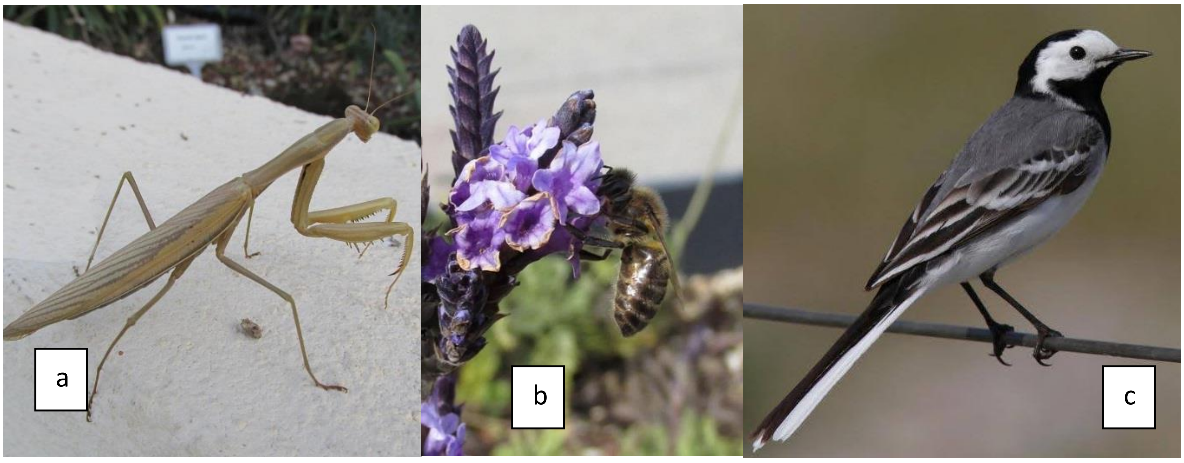
Many of the plants selected are summer deciduous but showed less effect in the test trays. A small number of species were found to be very susceptible to prey damage and disease. Six caterpillars of the endemic Maltese Swallowtail Butterfly were found feeding on the Rue (Ruta graveolens). The foliage of the Rue plants was totally consumed by the caterpillars but subsequently the plants recovered.

Figure 12. a) Maltese Swallowtail caterpillar (Papilio machaon, melitensis) feeding on Rue plants in the LifeMedGreenRoof Test Trays, b) Emergent adult butterfly.



The planting of the test trays attracted a good variety of insects and other arthropods including spiders. These in turn attracted larger predators including Praying mantis, insectivorous birds such as Redstarts and Wagtails and Geckos (Figure 13). A survey of the invertebrate biodiversity of the green roof was carried out by Mr Gilbert Gauci from the University of Stirling, Scotland as part of his M.Sc. dissertation. Mr Gauci concluded that the number and variety of invertebrates found on the green roof exceeded those discovered in open adjacent countryside. A detailed account of his study and findings is included in Appendix C.

Figure 13. Increasing biodiversity. Some of the animal species photographed on the LifeMedGreenRoof at the University of Malta including (a) honey bees (b) praying mantis and (c) white wagtails

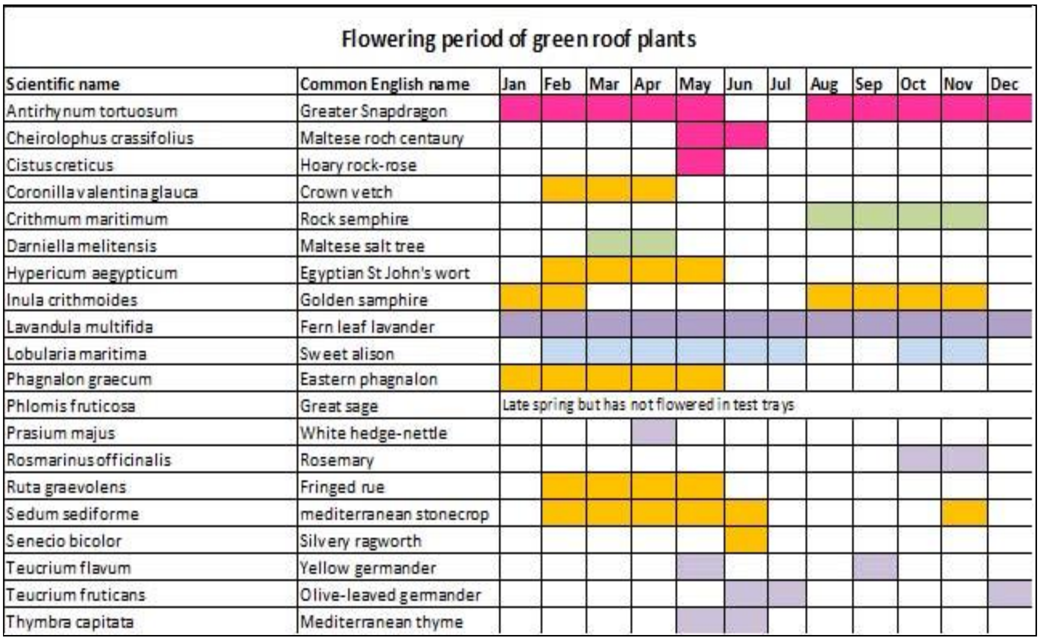


A method of scoring the plants on such criteria as length of flowering period and potential ground cover was established in order to provide a subjective comparison of the suitability of each species selected. This scoring chart is reproduced in Appendix A.

General maintenance was minimal and was limited to around 2 to 3 hours a month. Growth tends to be of low vigour therefore pruning is minimal. Weeding tasks were light especially when the cultivated plants began to spread over the surface. Any weeds that did appear were easily removed due to the open nature of the planting medium. Irrigation was carried out by hand at the beginning but an automatic watering system was installed later. The amount of water provided was reduced to 18 litres per $1m^2$ tray per week.

Another criteria for the selection of the plant species was the choice of species to provide year-long flowering in order to maintain colour and interest for users. The choice of flowering plants throughout the year also provided a continuous food source for honey bees and other nectar and pollen feeders. Figure 14 below shows the flowering periods for the green roof plants selected.

Figure 14. Flowering period of the selected green roof plants



Flowering period of green roof plants

Scientific name	Common English name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Antirhynum tortuosum	Greater Snapdragon												
Cheirolophus crassifolius	Maltese roch centaury												
Cistus creticus	Hoary rock-rose												
Coronilla valentina glauca	Crown vetch												
Crithmum maritimum	Rock semphire												
Darniella melitensis	Maltese salt tree												
Hypericum aegypticum	Egyptian St John's wort												
Inula crithmoides	Golden samphire												
Lavandula multifida	Fern leaf lavander												
Lobularia maritima	Sweet alison												
Phagnalon graecum	Eastern phagnalon												
Phlomis fruticosa	Great sage	Late spring but has not flowered in test trays											
Prasium majus	White hedge-nettle												
Rosmarinus officinalis	Rosemary												
Ruta graevolens	Fringed rue												
Sedum sediforme	mediterranean stonecrop												
Senecio bicolor	Silvery ragworth												
Teucrium flavum	Yellow germander												
Teucrium fruticans	Olive-leaved germander												
Thymbra capitata	Mediterranean thyme												

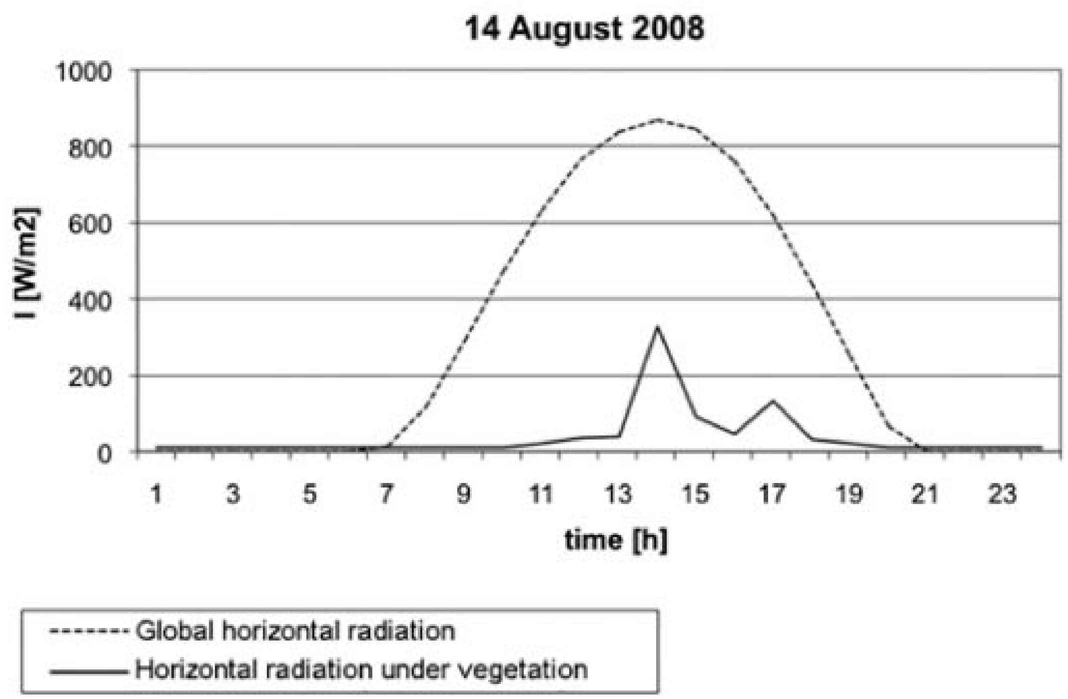
Effects of Planting on Cooling.

Urban Heat Island Phenomenon (UHI)

The presence of vegetation has been shown to decrease the urban heat island (UHI) effect experienced in many cities and towns. The UHI phenomenon is caused by the absorption of solar heat by common, massive, urban materials such as concrete and asphalt during the day and releasing this heat into the ambient air during the evening and night. This effect can raise urban temperatures by as much as 6°C when compared to more rural areas. It is thought that green infrastructure could provide a cooling effect by virtue of the plant processes of transpiration and evaporation (latent heat). Plants also have the effect of shading surfaces thus, it is suggested, they could further reducing heat gain (R. Fiorettia, A. Pallab, L.G. Lanzab, P. Principia,, August 2010,).

In addition, moisture is evaporated from the surface of the planting media which again through the absorption of heat required to change the state of liquid water to a gas (latent heat of vaporisation) effects a further reduction to the ambient temperature. Evidence gathered from experiments carried out by Fioretti et al (2010) on a green roof located in Ancona, Italy show that the vegetation layer diminished the solar radiation incident on the roof. This is illustrated in Figure15 below which compares the solar radiation monitored on the horizontal surface and below the foliage observed on the 14th August 2008 at the green roof of the Regional Council of Marche, Italy.

Fig 15. Comparison between solar radiation monitored on the horizontal surface and below the foliage observed at the green roof of the Regional Council of Marche (Italy) (R. Fiorettia, A. Pallab, L.G. Lanzab, P. Principia,, August 2010,)



There have been a number of studies that have attempted to calculate the cooling effect that green roofs would have on the heat island effect. Through computer modelling, Bass et al (B. Bass, 2003) found a 1% reduction in ambient air temperature for a 50% green roof coverage in Toronto. And planning officials in Tokyo expect a 0.83°C reduction of ambient temperatures with a green roof coverage of 1,200ha (Peck, 2001)

Research into the Cooling effect of Plants at the LifeMedGreenRoof Project, University of Malta

An investigation was designed within the test trays at the green roof laboratory at the University of Malta to assess the effect planting had on the thermal performance of green roofs (Morris V.L., 2016). In addition it was planned to look at two plants with different morphologies. Three 1m² trays were used and numbered from 4 to 6. Tray 5 was the control and did not contain any vegetation. All three trays were filled with 200mm depth of planting media and received equal irrigation.

Investigation. *Do plants make a difference to the thermal insulation performance of a green roof?*				
Tray No	Planting media	Depth (mm)	Plant species	Irrigated (litres per week)
4	√	200	Phlomis fruticosum	18
5	√	200	x	18
6	√	200	Sedum sediforme	18

Phlomis fruticosum, (Great Sage) as planted in Tray 4 is an upright plant with its sage like leaves held above the ground. It is partially summer deciduous so its shading of the ground is not as complete as Sedum sediforme which was planted in Tray 6 (see Figure 16 below) .

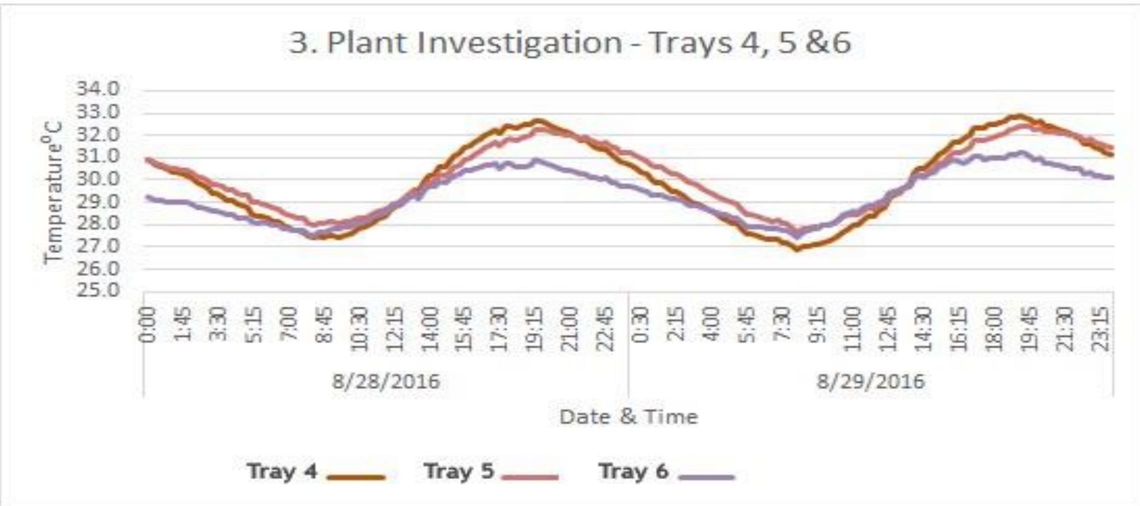
Figure 16 Images of Phlomis fruticcosum (left) and Sedum sediforme (right)

Phlomis fruticosum

Sedum sediforme

The results show that Sedum sediforme (Tray 6) appeared to be more effective than the Phlomis fruticosum (Tray 4) in moderating fluctuations of temperature. If compared with the unplanted Tray 5, it can be seen that the Sedum in Tray 6 reduced the peak heat gain by about 1.5^{o}C. (Figure 17 below).

Figure 17. Graph showing the influence of Plants on thermal performance.



Conclusions

Generally the plants under consideration remained healthy and to a large extent, resisted pests and disease. The plants initially selected for valuation were taken from the Garique, limestone habitat found in Malta as this harsh environment was thought to possess similar physical conditions that would be prevalent on a roof. Those species selected were perennial plants as it would thought that annuals would leave unacceptable spaces in the planting during the dormant, summer period. The assessment of the performance of the selected plants has indeed proved their general suitability for inclusion in future green roof installations. With the provision of a minimal amount of irrigation, the plants chosen survived through the long hot and dry Maltese summers. The majority of the plants which form the 'palette' of selected plants are native to the Maltese islands, however, more recently a small number of carefully selected 'exotic' plants were included to add greater diversity and interest. These introduced species were ones that had proved suitable for cultivation in Malta and had shown that they were non-invasive. An entomological study showed the value of the green roof planting in encouraging greater diversity of animal life.

The use of Biochar in one of the selected planting media (Mix 2) proved to be effective in increasing the water retaining capacity of the growing substrate. It was shown that the plants selected were low in their demand for irrigation. Evidence is presented that suggests that Green Roof planting can have a positive effect in moderating the Urban Heat Island Effect.

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Appendix A – List of selected native plants, their characteristics and suitability score.

No. species	Ref:	Image	Scientific Name	Common English Name	Maltese Name	Attractive foliage and/or flowers	Long flowering period: >3 m (Months in Brackets)	Resistance to disease/pests	Low Maintenance	Ground cover potential	Score
1	Tfr		Teucrium fruticans	Olive -leaved Germander	Zebbugija	•		•	•	•	4
2	Sed		Sedum sediforme	Mediterranean stonecrop	Sedum	•	• (6)	•	•	•	5
3	Hyp		Hypericum aegyphacum	Egyptian St.John's wort	Fexfiex ta'l-Irdum	•	• (4)	•	•	•	5
4	Phl		Phlomisfruticosum	Great sage	Salvja tal-Madonna	•		•	•		3
5	Cis		Cistus creticus	Hoary Rock rose	Cistus Roza	•		•	•		3
6	Pra		Prasium majus	White hedge-nettle	Te Sqalli	•		•	•	•	4
7	Thy		Thymbra capita	Mediterranean Thyme	Saghtar	•		•	•	•	4
8	Lob		Lobularia maritma	Sweet Alison	Buttuniera	•	• (8)	•	•	•	5
9	Ros		Rosmarinus officinalis	Rosemary	Klin	•		•	•	•	4
10	Lav		Lavandula sp.	Lavander		•	• (12)	•	•	•	5

No. species	Ref:	Image	Scientific Name	Common English Name	Maltese Name	Attractive foliage and/or flowers	Long flowering period: >3 m (Months in Brackets)	Resistance to disease/pests	Low Maintenance	Ground cover potential	Score
11	Ant		Antirryinum tortuosum	Greater Snapdragon	Papocci Hamra	*	* (10)	*	*	*	5
12	Cri		Crithmum maritimum	Rock Samphire	Buzbiez il Bahar	*	* (4)	*	*	*	5
13	Sen		Senecio bicolor	Silvery Ragwort	Kromb il-Bahar Isfar	*			*	*	3
14	Pha		Phagnalon graecum	Eastern Phagnalon	Lixka ta' Malta	*	* (5)	*	*		4
15	Pal		Cheirolophus crassifolius	Maltese Rock-centaury	Widnet il- Bahar	*		*	*		3
16	Rut		Ruta chaelepensis	Fringed Rue	Fejgel	*	* (4)	*	*		4
17	Cra		Crassula vallantii	Maltese Salt-tree	Xebb	*		*	*		3
18	Dar		Damiella melitensis	Maltese Salt-tree	Xebb	*		*	*		3
19	Cru		Crucianella rupestris	Rock Crosswort	Krucanella	*		*	*	*	4
20	Inu		Inula crithmoides	Golden Sampire	Xorbett	*	* (6)	*	*	*	5

Appendix B – Details of Planting Media.

Planting Medium Specifications

The planting medium used in the test trays and green roof was composed of a mix of both inorganic and organic elements. The inorganic elements were composed of crushed Lapillus and Pumice. These two inorganic minerals are derived from volcanic origins. These materials were selected as they do not include any of the clays and silts that form many ordinary 'soils.' Clays and silts could potentially block the filters and impede the underlying drainage system making up the green roof structure. The Lapillus and Pumice have the other advantage of being relatively light in weight due to their vesicular structure. This ensures an open, aerated composition to the planting medium which aids good drainage. The two crushed volcanic minerals were mixed with the organic coconut fibre, green waste, and Biochar as described below.

Surface view of the planting medium.

Inorganic Elements (crushed volcanic minerals)

Lapillus
Ø 5-10 mm
pH ≤ 8,5

Pumice
Ø 3-8 mm
pH ≤ 8,5

Organic Elements

Coconut fibre

Coconut fibre, or Coir is a natural fibre extracted from the husk of coconut and used in products such as floor mats, doormats, brushes, and mattresses. In horticulture, coir is a substitute for sphagnum moss because it is free of bacteria and fungal spores. Its hydroscopic properties provides a valuable source of retained water for use by the plants.

pH 4,5 - 7,5
electrical conductivity ≤ 50 mS/cm
(extraction in water 1:1,5) .

Green Compost

This is the product obtained by composting green waste materials. It provides valuable humus to the mix affording a range of plant essential elements. Composition is variable as it depends on the initial input of green waste. However, in the case of the green roof the green compost was specified to Italian Legislative Decree no. 75/2010.

Biochar

Biochar is charcoal used as a soil amendment. Like most charcoal, biochar is made from biomass, in this case wood pellets, burnt in the absence of oxygen (pyrolysis). It is used to improve soils as it enhances nutrient availability and also enables soils to retain nutrients and to some extent moisture for longer.

Percentage mix of planting media

The various components were mixed as per the following table to produce a homogeneous planting medium:

Component	% Volume
Pumice	30
Lapillo	35
Green compost	10
Coconut coir	10
Wood pellet biochar	15

Appendix C– Details of Case Study carried out by Mr Gilbert Gauci.

Do Green Roofs have the potential to attract pollinators? – A case study of the LifeMed Green Roof Project

Gilbert Gauci

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INTRODUCTION

Relatively long human presence on the Maltese Islands has led to considerable change in the landscape fabric. Consequently, urbanisation has led to the fragmentation and isolation of existing biotopes. Loss of natural wildlife directly affects pollinator abundance and diversity, which offer invaluable ecosystem services to society. Green Roofs are innovative urban ecosystems which have the potential to counteract the effects of habitat fragmentation and act as islands of biodiversity havens for pollinators. The study focuses on recording the quantity and diversity of pollinators visiting the Life Med Green Roof Project, funded by the EU LIFE + at the University of Malta. As a comparison for pollinator abundance and diversity, four reference sites i) conventional roof ii) ornamental garden and iii) two locations at Wied Għollieqa (Valley) within a 200m proximity were chosen.

PURPOSE OF THE STUDY

This research aims to address the following research areas:

- Record the abundance and diversity of pollinators visiting the Green Roofs and compare the results, with that of the four reference sites
- Compare the abundance and diversity of pollinators between the use of native and non-native species
- Analyse the correlation between weather variables and pollinator abundance

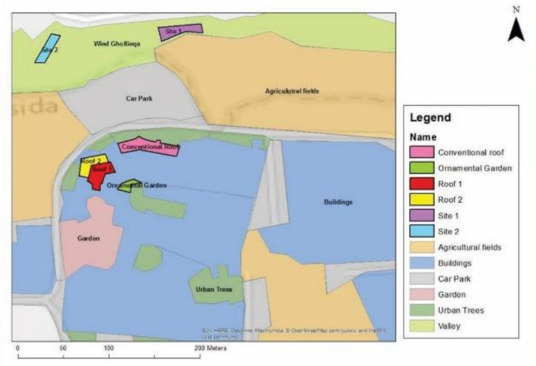

Figure 1: *GIS map illustrating the study sites and the different land uses surrounding the sites.*

METHODOLOGY

Data was collected over a span of five weeks, using hand netting as the standard method for data collection. Two sites were observed daily for five times a week between 8 am – 2 pm, both sites receiving four 25minutes sessions of data collection

RESULTS

977 pollinators were recorded on the green roofs, with roof 1 receiving 511 pollinators whilst roof 2 received 446 pollinators. 169 pollinators were recorded at the two locations of Wied Għollieqa, while 17 pollinators were present in the ornamental garden. No pollinators were observed on the conventional roof. 286 individuals of the *Apis mellifera ruttneri* (Figure 2) were recorded on the green roofs, ranking it as the most abundant pollinator on the green roofs. Other notable species on the green roofs included eight different species of hoverflies (Syrphidae), the *Halictus fulvipes* and the *Amegilla quadrifasciata* which where only observed on the green roofs.

The Simpson's Diversity Index indicates that the green roofs have the highest species richness of 22.02 (Roof 1: 12.47 + Roof 2: 9.55). While Wied Għollieqa had the second highest index of 12.63 (Site 1: 11.63 + Site 2: 1). The ornamental garden had an index of 1.97, while the conventional roof had no index as no species were observed.

Figure 2: The *Apis mellifera ruttneri* pollinating Malta's Endemic National Plant, the *Cheirolophus crassifolius*.

Native species attracted the majority (538) of the pollinators, while non-native species attracted 401 pollinators. Out of 12 native species in bloom (Figure 3), the majority of the pollinators were attracted by the *Sedum sediforme* (186) and the *Cheirolophus crassifolius* (152). Out of 6 non-native species in bloom (Figure 4), the *Gazania rigens (*144) and the *Lavandula multifidi* (184) attracted the majority of the pollinators.

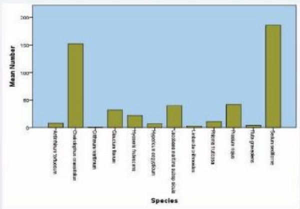

Figure 3: The bar graph is representing the total amount of pollinators attracted by native species.

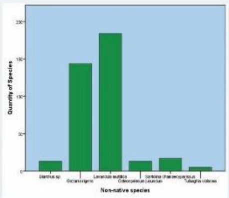

Figure 4: The bar graph is representing the total amount of pollinators attracted by non-native species.

A regression analysis was carried out to identify weather predictors that affect pollinators abundance. The regression analysis classified temperature and wind speed as having the most affect on pollinators abundance. A rise in temperature increases pollinator abundance, while an increase in wind speed, decreases pollinator quantity.

DISCUSSION

The Simpson's Diversity Index revealed that green roofs received higher species richness than Wied Għollieqa (valley). The index for the valley was probably lower, as the majority of the flowering species were dry, with only two species in bloom. In contrast, the green roofs had a total of 12 native shrubs and 6 ornamental species in bloom, thus offering pollinators a wider selection of species, which possibly could be the reason why more pollinators were present on the roofs. Furthermore, indigenous plant species attracted the majority of the pollinators. However, non-native plants still attracted a considerable number of pollinators. Therefore, pollinator abundance is mostly dependent on the species type (Figure 3 and 4). Increasing green roofs and utilising plant species that attract pollinators such as the *Apis mellifera ruttneri* will decrease the stress the species already faces that threaten it's existence.

Figure 5: The *Thomisus onustus* is one of the three types of crab spiders commonly observed on the green roofs.

Green roofs attracted further other species apart from pollinators, avifauna such as the common *Passer hispaniolensis,* reptiles such as the *Chamaeleo chamaeleon* and invertebrates, such as beetles and spiders. Three types of crab spiders were recorded on the green roofs (Figure 5). This evidence continues to support that green roofs attract a variety of fauna

CONCLUSION

Green roofs attract a diverse amount of pollinator diversity and abundance. The Simpson's Diversity Index suggested that the green roofs have an index of 22.02, which is almost twice fold higher than Wied Għollieqa. However, green roofs also shelter other species apart from pollinators. These results indicate, that if green roofs had to become more widespread, they have the potential to act as important stepping stone corridors, aiding in reinstating a broad scale ecosystem in the Maltese Islands, curbing the effects of habitat fragmentation.

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