Back On Our Map

Duke Of Burgundy Surveys, Captive Rearing and Reintroduction Methods

Dr Mic Mayhew

Contents

1. Introduction to BOOM

Back on Our Map (BOOM) aimed to engage communities in South Cumbria with their natural environment, by restoring the landscape and reintroducing and reinforcing locally threatened or extinct native species. National Lottery players supported the £2m project, alongside several other public, private and charitable sector organisations. Led by the University of Cumbria, BOOM worked closely in partnership with Morecambe Bay Partnership, and lead partners including Cumbria Wildlife Trust, Natural England and Forestry England.

The project restored habitat and reintroduced species across a network of protected areas including Sites of Special Scientific Interest (SSSIs), National Nature Reserves (NNRs) and Arnside and Silverdale Area of Outstanding Natural Beauty (AONB). It covered an area of 600km2, extending along the lowlands of Morecambe Bay from Barrow-in-Furness in the west to Arnside and Silverdale in the east and Ambleside in the north (Figure 1.1).

Figure 1.1: Map of the BOOM working area.

BOOM reintroduced and expanded the range of the hazel dormouse, Duke of Burgundy and small blue butterfly, goldilocks aster, great and oblong-leaved sundew, green-winged orchid, maidenhair fern, spiked speedwell, and aspen (table 1.1). A reinforcement of a Duke of Burgundy population was carried out on the Graythwaite Estate. The pine marten community-based feasibility study identified suitable locations for future reintroduction. For the Corncrake, public engagement sound walks raised awareness of the species.

Table 1.1: Species included in the BOOM project.

Common Names	Scientific Name	BOOM Objectives
Aspen	*Populus tremula*	Reintroduction
Corncrake	*Crex crex*	Public Engagement and Interpretation
Duke of Burgundy	*Hamearis lucina*	Reinforcement
Goldilocks Aster	*Galatella linosyris*	Reintroduction
Great Maidenhair fern	*Drosera anglica*	Reintroduction
Green-winged Orchid	*Anacamptis morio*	Reintroduction
Hazel Dormice	*Muscardinus avellanarius*	Reintroduction
Maidenhair Fern	*Adiantum capillus-veneris*	Reintroduction
Oblong-leaved Maidenhair fern	*Drosera intermedia*	Reintroduction
Pine Marten	*Martes martes*	Feasibility Study
Small Blue	*Cupido minimus*	Reintroduction
Spiked Speedwell	*Veronica spicata*	Reintroduction

Across south Cumbria, the project engaged a wide range of community groups, volunteers and members of the public. Reintroduction-based social activities and training events helped communities get involved with the BOOM species reintroductions.

This document covers the work BOOM did on the Duke of Burgundy, including the survey techniques, reintroduction methods and community engagement events.

2. Species Background

The Duke of Burgundy (*Hamearis Lucina*; DOB) is a rare butterfly occurring in small discrete colonies in scrubby, herb rich chalk grassland and coppiced woodland clearings. Adults fly between early May and mid-June and eggs are laid in small batches on primrose (*Primula vulgaris*) (Fig. 2.1) or cowslip (*Primula veris*) plants in sheltered sunny locations (Thomas and Lewington, 1991; Oates, 2000; Ellis et al., 2010). The geographic range of the DOB is primarily in central southern England, with isolated populations on the limestone of south Cumbria/north Lancashire and the north Yorkshire moors (Ellis et al., 2010). The population in the UK has declined by almost 40% since 1979 but has stabilised over the last 20 years with a moderate decline of 7.0% (Asher et al., 2001; Fox et al., 2006). Many colonies have been rendered extinct or reduced to a few individuals since the 1970s. The DOB is a Section 41 species protected under Schedule 5 of the 1981 Wildlife and Countryside Act, a UK BAP priority species and a high priority species for Butterfly Conservation.

As a habitat specialist, the species has declined in many areas since 1950 due to the cessation of woodland management and overgrazing by sheep with associated reductions in the distribution and abundance of larval food plants (Bourn and Warren, 1998). Climate change and atmospheric nitrogen deposition may also be contributing to the DOB's decline through the impact of warmer and wetter weather on specific stages of the species lifecycle and through the increase in the growth rates of dominant plants such as bramble that can shade out and smother larval food plants (Klop et al., 2015; Roth et al., 2021).

The DOB is currently found at six locations in Cumbria and north Lancashire: in the southern part of Grizedale Forest, at two sites in the Rusland Valley, on Whitbarrow National Nature Reserve (NNR) and Kendal Fell in south-east Cumbria, and at Gait Barrows National Nature Reserve (NNR) in north Lancashire (Skelcher, 2019). The populations at Whitbarrow and Gait Barrows are both long established, primarily within coppiced woodland and sheltered limestone grassland glades, while the populations in the Rusland Valley and in Grizedale Forest are recent discoveries and mainly associated with stands of purple moor-grass grassland (Fig. 2.2) (Skelcher, 2019). The small population at Kendal Fell appears to be the result of a recent unauthorised introduction. Records from Cumbria and Lancashire suggest that there has been a significant reduction in the distribution of the butterfly since the 1980s and a substantial contraction throughout the Arnside & Silverdale AONB with only one small remaining population in Gait Barrows NNR (Skelcher, 2019).

Over the last few years many existing and potential sites for DOB in South Cumbria have been restored by Cumbria Wildlife Trust, Butterfly Conservation and other regional NGOs and statutory organisations with long-term commitments to management prescriptions that will

maintain these sites in suitable condition (Skelcher, 2019). However, some DOB populations are so small that they are likely to go extinct, despite improvements to mid-successional habitats, because of stochastic events and inbreeding unless populations are reinforced through captive breeding.

Figure 2.1. Primroses in mid-successional habitat at Broadsyke in the Rusland Valley.

Figure 2.2. DOB habitat comprising a glade of purple moor grass with primroses sheltered by regenerating downy birch (*Betula pubescens*), heather (*Calluna vulgaris*) and juniper (*Juniperus communis*), Broadsyke, Rusland Valley.

3. Reintroduction Objectives

Aims

The aim of the DOB project is to work with local communities and key partner organisations such as Butterfly Conservation, Natural England and the Cumbria Wildlife Trust to reinforce existing DOB populations in South Cumbria and create new satellite populations to expand the geographic range and metapopulation structure of the species.

Objectives

- Identify a selection of potential donor and recipient sites as the focus for species restoration activities during the term of the BOOM project. They should form part of the historic range of the species, comprise suitable habitat (good condition or potential for improvement), and contribute to a metapopulation structure.
- Establish a DOB population and habitat monitoring programme through the implementation of various seasonal surveys (larval food plant/adult timed count/egg count) conducted by members of the Back On Our Map (BOOM) project with trained volunteers and project partners.
- Design and implement a DOB captive breeding programme aligned with IUCN guidelines (2013) through the collection of eggs and ex situ propagation of larvae and pupae with the consent and supervision of Butterfly Conservation and support of trained volunteers.
- Undertake habitat restoration works at sites with established DOB populations or at potential reintroduction sites through the management of scrub to maintain areas of mid-successional habitat and the ex-situ propagation and planting out of larval food plants such as primroses and cowslips.
- Engage communities in project activities including university students, members of the public and local stakeholders to increase their knowledge base, provide opportunities for upskill and provide access to nature with far reaching health and welfare benefits.

3.1. Project Locations

Due to the short timeframe of the BOOM project and limited staff capacity, a site prioritization exercise was carried out to determine the spatial focus of DOB activities based on the following criteria at a site level:

- The availability of a sympathetic landowner/land manager who is happy to cooperate with BOOM project officers and consider long-term management prescriptions to support DOB populations.
- The presence of suitable habitat in good condition or recovering condition with the potential for habitat restoration through scrub management and planting of primroses/cowslips.
- Sites with extant DOB populations and connectivity to adjacent habitat networks with the potential for natural recolonization and the establishment of a functional metapopulation.
- Range wide sites with extant populations of DOB or sites with suitable habitat and historic records of DOB where the species is currently extinct.

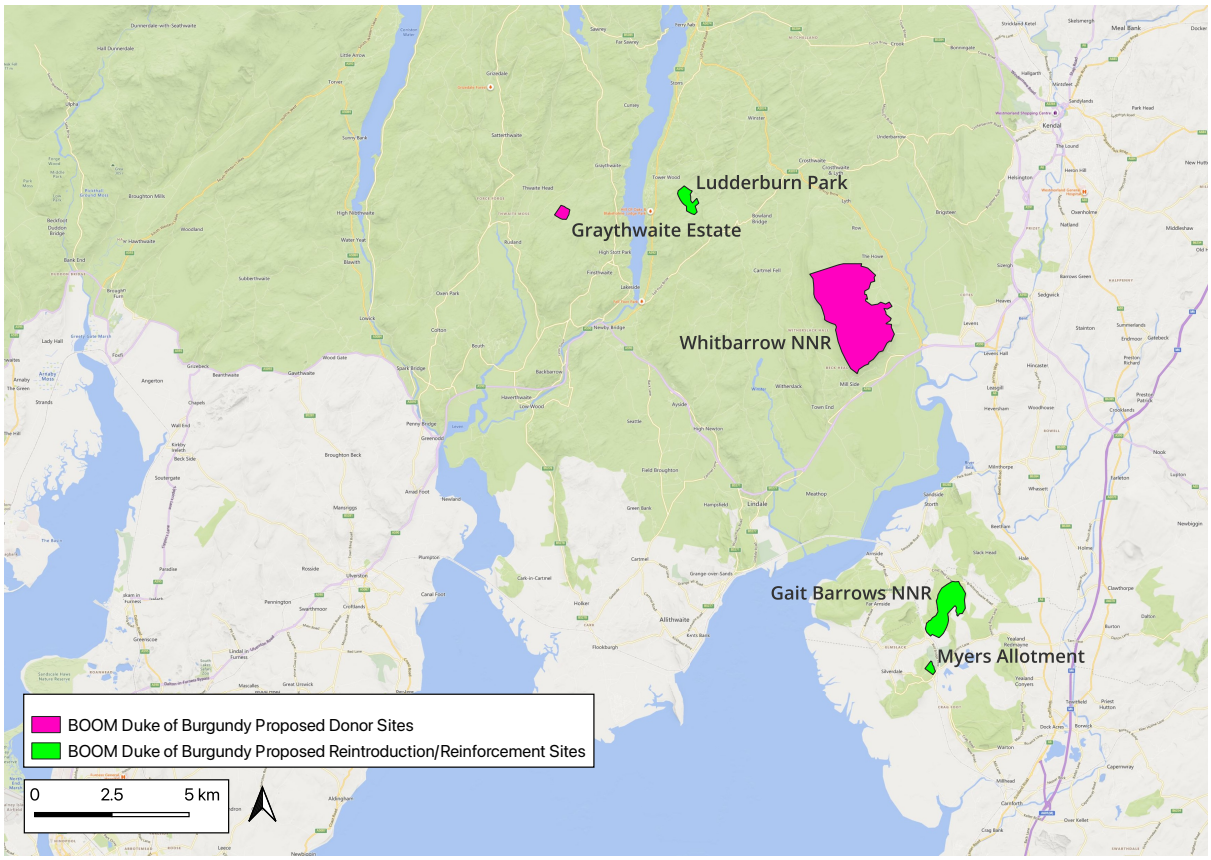

Figure 3.1: Sites prioritized for Duke of Burgundy conservation activities during the term of the BOOM project (September 2019 -January 2024)

Donor Sites

Whitbarrow NNR and Graythwaite Estate in the Rusland valley (Fig. 3.1.) support the largest colonies of DOB in Northwest England (Skelcher, 2019) and provide opportunities, as donor sites, for captive breeding. Gait Barrows NNR supports the last small colony of DOB in the Arnside and Silverdale AONB (Skelcher, 2019) with dispersal corridors to Myers Allotment, a small reserve managed by Butterfly Conservation. During the term of the BOOM project, habitat conditions have improved markedly for DOB at Gait Barrows and Myers Allotment due to the planting of larval foodplants and creation of mid-successional habitat.

The two DOB donor sites in the Rusland Valley and on Whitbarrow NNR currently hold the largest remaining populations in the north-west of England (Skelcher, 2019). Surveys of adult butterflies during the flight period in May and early June 2020/21 were undertaken to estimate the population size and determine the suitability of the sites for the harvesting of eggs and larvae.

BOOM project officers have negotiated access agreements with the landowners at both the potential donor sites and SSSi consent was granted from Natural England to harvest eggs or early-stage larvae from Whitbarrow NNR. However, discussions with the landowners on Whitbarrow and analysis of adult timed count and egg count data, revealed that the population was not large enough to tolerate the removal of stock for captive breeding purposes.

Broadsyke in the Rusland Valley was the only DOB site chosen as a donor site for the removal of eggs and larvae in June 2021 and 2022.

Reintroduction Sites

Release sites for DOB were selected following the criteria listed in section 3.1 and after consultation with colleagues from Butterfly Conservation. The two sites which were selected as candidate release sites were Ludderburn Park (Fig 3.1.) an area of scrubby limestone grassland in private ownership with abundant foodplants in the parish of Cartmell Fell, and Gait Barrows NNR in the Arnside and Silverdale AONB. Ludderburn Park is an area of high quality mid-successional habitat with light grazing pressure from sheep which does not currently hold a population of DOB. Therefore the release of captive bred stock at this site would constitute a reintroduction. By contract Gait Barrows NNR retains a small extant DOB population which would be reinforced through the release of captive bred late stage pupae.

3.2. Partners and Consents

The principal partner and expert advisor for the DOB project was Butterfly Conservation (BC) with many activities delivered jointly with members of the Cumbria and Lancashire branches of BC. All captive breeding work, conducted by BOOM project officers, was undertaken in

accordance with recommendations on Collecting Breeding and Photography (Butterfly Conservation, 2018) and policy on Introductions and Reintroductions (Butterfly Conservation, 2010). Other important partners included private and public landowners of potential donor and recipient sites (Table 3.2).

Table 3.2: Summary of partners involved with the Duke of Burgundy project

Name of organisation	**Key contact (s)**	**Role in the BOOM DOB project**
Butterfly Conservation	Martin Wain Dave Wainwright Chris Winnick	Expert advisors (captive breeding/monitoring). Habitat management (winter work parties). Larval foodplant propagation. Hosting conferences/workshops
Natural England	Glen Swainson Jim Turner	Access to Gait Barrows NNR. SSSI consents for DOB translocation. Habitat advice/management (winter work parties).
Graythwaite Estate	Edward Sandys	Access to Graythwaite Estate. Authorization to use donor population for captive breeding programme. Habitat advice/management (winter work parties).
HMP Haverigg	Brendan Ashton	Prisoner capacity used for growing larval food plants. Prisoner support with habitat management.

3.3. Donor Site Surveying

Larval food plants

Early in the DOB project, baseline surveys of cowslips and primroses were undertaken in May 2020 at priority sites such as Gait Barrows NNR (Fig. 3.2) to establish the geographic range and abundance of plants as the basis for a network of compartments which would be monitored throughout the BOOM project term. QGIS mapping was used to determine connectivity between compartments and locate the most suitable sites for future planting schemes. The number of whole plants (not flower heads) was estimated for each compartment along a network of walked parallel transects.

From 2021 onwards surveys in April/May were also conducted to monitor the survival of food plants that were planted during the previous year to establish temporal and spatial impacts on

the growth rates and survival of larval food plant. Overall cowslips planted on deeper soils in the autumn rather than spring months showed faster growth rates and higher rates of survival.

Food plant surveys were also used to assess the level of larval feeding damage as a proxy for successful DOB breeding as the larvae are nocturnal and very challenging to identify. DOB larvae create a dense scatter of small holes or windows on the leaf characteristically preserving the leaf veins (Skelcher, 2019). Given the relatively short flight period of adult DOB during May and early June, larval foodplant surveys can be extended throughout June and July to survey the species. Foodplant surveys were conducted at Gait Barrows NNR between 2021 and 2023 to identify the dispersal of DOB adults from core compartments on the east side of the reserve.

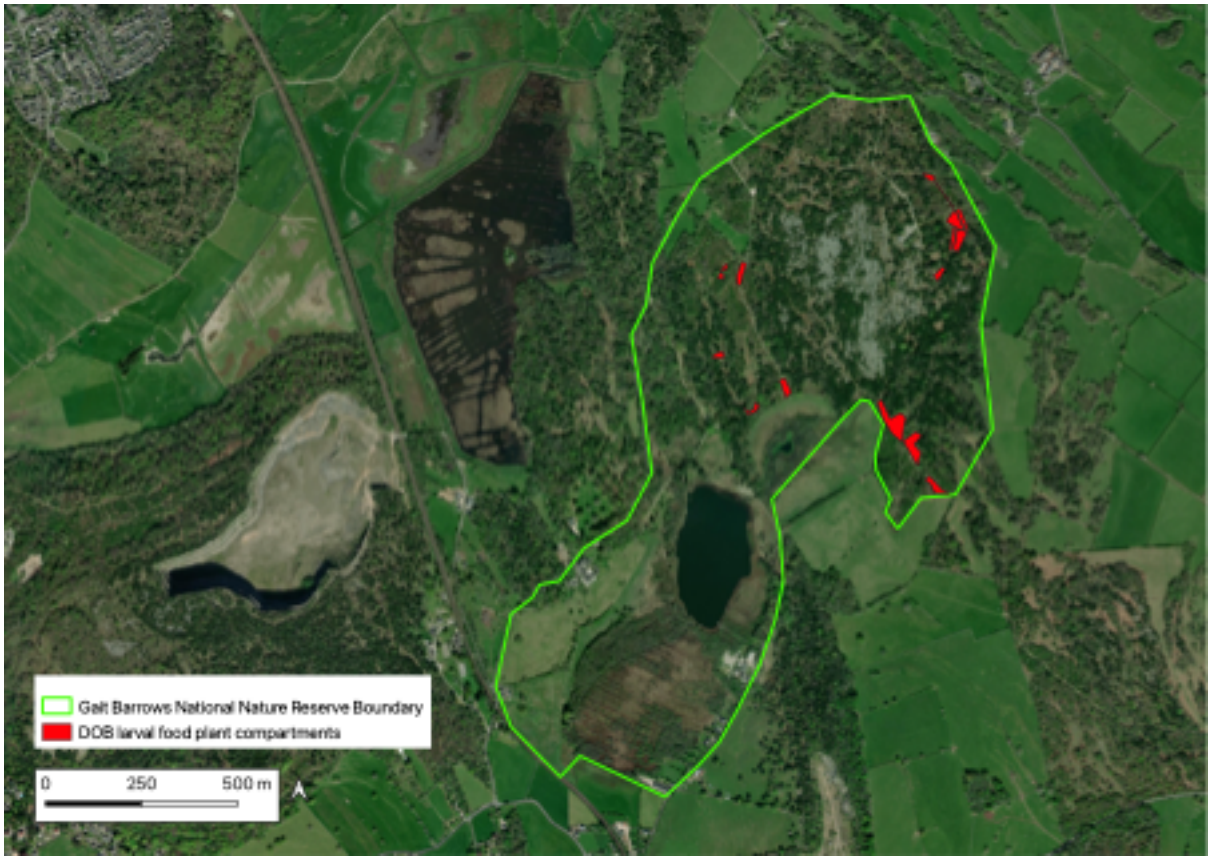

Figure 3.2: DOB compartments with abundant cowslips and/or primroses at Gait Barrows NNR.

Adult timed counts

DOB adults were surveyed weekly using timed count methodology from the UK Butterfly Monitoring Scheme during the flight period in May and early June. Counts were undertaken at Gait Barrows NNR, on Broadsyke in the Rusland Valley and on Whitbarrow NNR between 10.00am and 4.30pm on warm, sunny days with low wind speeds (13 - 17°C, at least 60% sunshine). Generally, two surveyors worked together to cover all areas of each compartment by walking slowly along parallel transects and counting all the butterflies they saw. The total

time taken to survey a compartment varied with compartment size and effective communication between the surveyors was important to avoid double-counting and population overestimates. Metadata relating to each compartment was recorded on field sheets (Table 3.3) including the number of butterflies detected, date, site and compartment name and grid reference, temperature, percentage sunshine during the survey period and wind speed.

Table 3.3. Compartment level data for DOB adult timed counts in 2023 on Broadsyke in the Rusland Valley and summary data of maximum daily counts across all Broadsyke compartments between 2019 and 2023.

Site Name	Compartment Name	Date	Time Start	Time Finish	Temp C	% Sun	Wind BS	Number
Broadsyke	A	16.05.23	11.29	11.45	14	40	2	1
Broadsyke	B	16.05.23	11.50	12.00	15	60	2	3
Broadsyke	C	16.05.23	12.05	12.15	15	60	2	0
Broadsyke	D	16.05.23	12.20	12.30	13	40	2	1
Broadsyke	E	16.05.23	12.38	12.48	13	60	2	0
Broadsyke	F	16.05.23	13.00	13.15	14	60	2	0
Broadsyke	G	16.05.23	13.20	13.35	14	60	2	1
Broadsyke	H	16.05.23	13.45	14.05	14	50	2	4
Broadsyke	BSE	16.05.23	14.10	14.30	15	40	2	4
Broadsyke	A	25.05.23	14.00	14.15	18	100	1	6
Broadsyke	B	25.05.23	14.20	14.30	18	100	1	1
Broadsyke	C	25.05.23	14.35	14.45		100	1	0
Broadsyke	D	25.05.23	14.50	15.00	18	100	1	1
Broadsyke	BSEX	25.05.23	15.05	15.15	18	100	1	5
Broadsyke	E	25.05.23	15.20	15.30	18	100	1	2
Broadsyke	F	25.05.23	15.40	15.50	18	100	1	4
Broadsyke	G	25.05.23	15.55	16.05		100	1	0
Broadsyke	H	25.05.23	16.05	16.20	18	100	1	5
Broadsyke	BSE	25.05.23	16.20	16.30	18	100	1	8

Year	Broadsyke max daily counts (all compartments)
2019	56
2020	? (Covid 19)
2021	17
2022	25
2023	32

Recommendations

Larval foodplants are easier to identify when they are in full bloom and before they wilt. Therefore, surveys of primroses should be undertaken from April and cowslips from May onwards. The timing of flowering will vary from year to year depending on climatic factors.

Primroses and cowslips that have been propagated to enhance DOB habitat should not be planted out in areas of limestone pavement with very shallow soils as their survival and growth rates are lower than plants in deep soils and they are more vulnerable to desiccation during spring/early summer drought periods.

Larval foodplant damage surveys are a non-invasive way of confirming DOB presence and breeding in an area and the abundance and range of damaged food plants can provide a relative index of population size and dispersal from year to year at a compartmental level. The identification of eggs and larvae on foodplants to confirm breeding requires physical handling of individual leaves and should be avoided due to the risk of crushing.

The duration of an adult timed count survey should vary with the size of the compartment to avoid missing any individuals. Surveyors should take great care to prevent the crushing of larval foodplants on the transect route by adopting a slow walking pace. When an adult DOB

is flushed up on the wing, the surveyor should follow the butterfly until it settles on a plant to confirm its identity and avoid misidentification with small brown day flying moth species.

3.4. Habitat Management and Preparation

Seasonal habitat restoration activities were conducted by DOB project officers with support from BOOM and BC volunteers at priority sites with extant DOB colonies and/or potential recipient sites. The two most important activities included winter work parties (Fig. 3.3) between October and March to control scrub encroachment and maintain mid-successional habitat and the ex-situ propagation and planting out of larval foodplants.

Winter work parties

Work parties were led by an experienced member of BC or BOOM who was responsible for briefing the team of volunteers on proposed activities, associated risks and potential beneficial impacts for the target species. Most work parties were arranged between 10.00am and 3.00pm, avoiding inclement weather conditions, and scrub management was undertaken using hand tools such as loppers and bowsaws with suitable PPE (gloves/goggles/boots) to avoid injuries to eyes and extremities. The aim was to cut back and remove bramble (*Rubus fruticosus*) and fast growing tree saplings such as birch (*Betula* spp.), blackthorn (*Prunus spinosa*) and hawthorn (*Crataegus monogyna*) to create a mosaic of sheltered openings on the forest floor which would promote the growth of larval food plants without removing the three dimensional structure in the field layer which is characteristic of mid-successional habitat and favoured by DOB. In addition to managing areas with extant DOB populations, scrub removal was often undertaken to create habitat corridors between DOB colonies or to enable dispersal and colonization of new compartments of suitable habitat to expand the meta population structure.

Figure 3.3: Scrub removal to enhance DOB habitat at Whitbarrow NNR, November 2021

Larval foodplant propagation

Seed of local provenance was collected from cowslip and primrose plants during the summer months and sourced from BOOM project partner sites. The fresh seed was sown onto SylvaGrow organic seed compost soon after collection and the seedlings were grown on through the autumn and winter by project volunteers including prisoners from HMP Haverigg. In 2020/21 most planting was conducted during the spring months but periods of warm dry weather in May/June resulted in poor growth rates and the desiccation and loss of larval food plants at some sites. Plantings in 2022/23 were more successful as they were conducted in the autumn to benefit from warm moist soils that are characteristic of the season. Planting sites were chosen in openings between scrub with sufficient soil depth to enable root development. Cowslips/primroses were planted in small groups of six or more to ensure a food supply for developing larvae through all four instar stages. During the term of the BOOM project, cowslips were planted at Gait Barrows NNR, Myers Allotment, Whitbarrow NNR and on Kendal Fell.

Recommendations

Winter work parties are a great opportunity to engage stakeholders with local communities and should be used as a vehicle to grow knowledge and awareness about the conservation needs and specific habitat requirements of priority butterfly species.

The clearance of scrub with hand tools such as loppers and bowsaws is slow and very labour intensive. On large reserves such as Whitbarrow NNR other methods such as conservation grazing with heritage cattle breeds and the use of brush cutters should be deployed to expand the scope of scrub clearance activities.

The optimum time for planting out cowslips and primroses is in September and October when the soil is moist and warm to enable establishment and root growth before the winter months. The planting out of larval foodplants in the spring and early summer may coincide with drought periods which will impact on growth rates and survival.

Cowlslip and primrose propagation activities are suitable for a wide range of unskilled and skilled volunteers as the species readily germinate from seed and are easy to prick out and maintain.

3.5. Captive Breeding

Identifying Eggs and Larvae

The small white eggs (Fig. 3.4a) are laid from mid-May onwards in small clusters on the underside of primrose and cowslip plants (Sparks et al., 1994; Oates, 2000). Female DOB prefer to lay eggs in more sheltered areas with a warm microclimate and often choose larval foodplants growing adjacent to bracken, grass tussocks and other scrubby plants (Sparks et al., 1994; Oates, 2000).

The eggs take 7-21 days to hatch depending on weather conditions and first instar larvae can be found from early June onwards on either side of fresh primula leaves (Oates, 2000; Skelcher, 2019). Most feeding activity occurs during the night (Oates, 2000). Larvae are pale brown in colour with a darker brown stripe on their upper or dorsal side running the length of the body (Fig. 3.4b) (Skelcher, 2019).

Figure 3.4: a) DOB eggs on underside of cowslip leaf; b) 3rd instar larvae with dark dorsal stripe.

Harvesting

Only eggs or early-stage larvae were harvested. Prior to harvesting eggs/larvae were counted in predetermined compartments within a defined time period and their locations were marked with a small brightly coloured flag. BOOM project officers and a small number of trained volunteers then harvested no more than 10% of the detected population from different locations on site to maintain genetic diversity and prevent over-harvesting in discreet areas. The safest harvesting method is to use sharp scissors or a scalpel to gently cut the leaf with the eggs/larvae at the base and transfer it to a small, clean Tupperware box lined with tissue paper. The harvesting locations were recorded with a GPS waypoint and all required entries on the Field Recording Sheet were completed.

Transport

Prior to transport, the individual leaves with attached eggs/larvae were slotted into moistened florist's 'oasis' in a sealed plastic container. The containers were secured during transport to avoid any unnecessary movement which could cause stress or damage. The oasis will keep individual leaves green while the eggs are maturing, particularly if they are cut with a long section of stem. Eggs were carefully monitored until they experienced a colour change to brown as they approached hatching. At this point a small section of the leaf carrying the eggs was excised and pinned to the underside of a healthy leaf on the living plant within the rearing cage.

Rearing Cage Design

Rearing cages (Fig. 3.5) can be designed from plastic containers or terracotta plant pots which should be thoroughly cleaned, rinsed and dried before use to avoid chemical residues and parasites. The primulas were examined with great care to remove all predators including parasitic wasps, spiders, slugs and snails before they were planted into sterile compost. Immersing the primulas in water for 24 hours also helps to control predators. After planting,

the larval foodplants were watered thoroughly before covering them with mesh. A thin metal (coat hanger) frame was anchored in the growing medium to support a mesh of fine gauge midge netting which was sealed around the outside of the pot with an elastic band or suitable tie.

Figure 3.5: Two different designs of DOB rearing cages

Positioning of Rearing Cages

To maximize survival, the rearing cage was placed outside to expose eggs/larvae to similar weather conditions to those at the donor site. Indoor conditions (even in an outhouse or garage) are likely to be too hot and dry and may cause harm. It is very important that rearing cages in an outdoor setting are elevated or otherwise protected from rodents, birds and other predators. A sheltered position was identified with adequate airflow to avoid the rearing cage being damaged by heavy rain and strong winds. It was exposed to sunlight during periods of the day to allow the foodplants to photosynthesize and to provide the larvae with access to ultraviolet light.

Rearing Cage Maintenance

The larvae moult three times (four larval instars) before they pupate (Skelcher, 2019). The release cage was monitored daily during those six weeks to identify parasites and record the progress of the eggs/larvae. To reduce the risk from disease and parasites the eggs and larvae were distributed between several rearing cages with no more than four larvae per cage. Be aware that the leaves of the larval foodplant will be consumed more rapidly with a greater number of larvae and as the larvae moult and mature.

The following checks were conducted on a daily basis:

A. Larval foodplant

A torch was used to check the health of the primula and the extent to which the leaves had been consumed by the larvae. By restricting the number of larvae in each rearing cage the larval foodplant may be able to support the larvae to the pupal stage. However, If the leaves are turning yellow and the plant is wilting or most of the leaf surface area has been eaten, the larvae will need to be moved onto a fresh plant. The larvae demonstrated preferred hiding spots such as under the rim of the pot, in folded up dead leaves, in any folds in the netting, and between the stalks and stems at the base of the plant. Therefore, all areas were systematically searched until the number of larvae matched the number of eggs harvested before using a teaspoon and a fine paintbrush to move them into a holding receptacle before releasing them together onto the new plant. The primulas were watered as required once or twice a week at the base of the plant to avoid dislodging eggs/larvae from the leaves and the netting was only removed if there were no larvae attached to the inside surface. Following watering the netting was carefully repositioned and sealed around the foodplant.

B. Eggs/Larvae

There was no need to remove the netting to perform daily checks on the eggs and larvae and a torch was used to count and evaluate the health of the larvae through the mesh. Signs of health included movement, feeding activity and growth of the larvae over time. Be aware that a temporary interruption to feeding is normal before a moult and before pupation. Damage to the larval foodplant was used as indirect evidence of feeding activity as the larvae produced a characteristic pattern of holes or windows in the leaves without damaging the leaf veins (Fig. 3.6) (Skelcher, 2019).

Figure 3.6. Characteristic pattern of larval feeding damage on cowslip leaves with a patchwork of holes between the leaf veins.

C. Predators/parasites

The inside of the release cage was checked for evidence of any flying insects, spiders and slugs/snails which were removed immediately following detection. Predators can emerge from the soil substrate or from the larval foodplant despite initial checks when the rearing cage was set up.

Care of Overwintering Pupae

DOB pupae are rarely seen in the wild as they occur at the base of grass tussocks associated with leaf litter (Oates, 2000). The rearing cage was suitable as an overwintering site but required modification by cutting and removing the remains of the foodplant and by depositing a small amount of dry grass and/or leaf litter on the soil surface. Before these modifications were carried out, all the pupae were located and settled onto the soil surface. The larvae pupated in various locations including the soil surface, the larval foodplant and the netting. Those on the food plant or the netting were removed with no direct contact by cutting out the small section of leaf/net which contained the pupa. When all pupae were secure on the soil surface the grass/leaf litter was gently placed on top of them before the netting was replaced. Prior to use the leaves/grass were checked for parasites and stored in the freezer for 24 hours to sterilize them. Routine checks of the overwintering pupae were carried out twice weekly.

Results

A dozen first instar larvae were harvested from Broadsyke (Graythwaite Estate) for a captive breeding trial in July 2021 and distributed amongst four project officers/volunteers for rearing through larval and pupal stages. Of the 12 larvae, nine survived to late-stage pupae and were placed in a release cage on Broadsyke on the 22 April 2022. All pupae emerged as adults within the first two weeks in May 2022. In May 2022, project officers harvested 50 eggs from the same donor site and 60% (n=30) emerged as adults the following May to reinforce the population at Broadsyke. Following discussions with Butterfly Conservation it was decided that the number of late stage pupae available in May 2022 and 2023 from donor stock collected the previous year was not sufficient to establish a new satellite colony.

Table 3.5: results of captive breeding and reinforcement of DOB at Broadsyke (Graythwaite Estate) between 2021 and 2023.

Harvesting date	07 July 2021	24 May 2022
Max. daily egg count	40	165
No eggs/larvae harvested	12	50
% eggs/larvae harvested	30	30
% survival to emerging adults	75	60
Timing of emergence	02.05.22-09.06.22	09.05.23-16.05.23

Recommendation

Seek all the necessary consents from private landowners and statutory bodies (e.g. SSSI consent) prior to the implementation of a captive breeding programme.

The decision to harvest DOB eggs/larvae for captive breeding purposes is dependent on survey results at the donor site and should be made following expert advice from Butterfly Conservation. Eggs/larvae should be harvested across all compartments to maximise genetic diversity and no more than 10% of the total population recorded on survey, should be removed.

It is preferrable to collect eggs rather than larvae for captive breeding as eggs are easier to locate individually or in small clumps on the underside of cowslip and primrose leaves and the survival of eggs and rates of emergence of first instar larvae are high under optimal conditions.

The optimal time to collect eggs will vary with location and climatic conditions but in south Cumbria egg surveys should be conducted weekly from mid-May onwards. Volunteer

training should be provided in egg survey, handling and transport methods to minimise the potential for harm to larval food plants and eggs/larvae during the captive breeding process.

To reduce mortality at all life stages during the captive breeding process, the rearing cages should be located in a suitable outdoor location which is exposed to local ambient conditions. The rearing cages should be hung or otherwise elevated off the ground to prevent access by rodents and invertebrates. They should be sheltered from wind, heavy rain, and direct sunlight.

The positioning of release cages at the recipient site should also be in an elevated sheltered and shaded location to prevent desiccation and mortality of pre-emergent pupae. Pupal cases should be retained to provide biological material for molecular research on the comparative genetic diversity of regional DOB populations.

3.6. Reintroduction Methods

Release Cages

In controlled conditions, as part of a captive breeding program, it is possible to translocate and release newly emerged adults but safer and logistically more straightforward to reintroduce pupae. Adult butterflies that emerge in captivity could be damaged in the release cages or during transport and may be disorientated upon release such that they disperse away from suitable habitat. The batch of pupae are also likely to hatch at different times requiring multiple trips to the recipient site to release small numbers of adult butterflies.

During the last two weeks of April and the early part of May pupae were checked daily for a colour change from cream to darker brown to indicate emergence. When the colour change occurred, the pupae were removed from the rearing cage using a spoon and fine paintbrush and placed together on tissue paper in a sealed tupperware box. On arrival at the recipient or release site the pupae were transferred to the release cage (Fig. 3.7) which was suspended from a tree branch to avoid terrestrial predators and protected from the rain with a thin plywood roof. The holding tray of the release cage was perforated to enable drainage and the pupae were placed within a layer of sterile litter. On emergence the adult butterflies flew upwards towards the light and escaped through the opening at the top of the funnel shaped mesh. The release cage was checked at least twice weekly to record emergence dates and assist any adults out of the cage.

Figure 3.7: Release cage in situ at Broadsyke, Rusland Valley

Recommendations

As soon as a colour change is identified in any of the overwintered pupae, all stock should be moved from the rearing to the release cage(s) and covered in a layer of sterile leaf litter. The release cage should be monitored at least twice a week and the dates of emergence of viable pupae and dates of pupal mortality (colour change to black/dark brown and shrinkage of pupa) should be recorded.

Post-release monitoring should be conducted once or twice weekly at the donor sites until the end of the flight season in mid to late June using adult timed count methodology (see section 3.3). This could be followed by larval food plant damage surveys to record evidence of reproduction.

3.7. Monitoring

Recommendations

It is recommended that DOB project partners such as Butterfly Conservation and the staff at Graythwaite Estate continue to monitor the priority donor sites beyond the term of the BOOM project to measure abundance and range/expansion/contraction.

In subsequent good breeding years if the numbers of eggs and larvae are deemed high enough on the basis of survey results, further captive breeding programmes should be implemented using BOOM and Butterfly Conservation methodologies to establish new satellite colonies and expand the DOB metapopulation structure in south Cumbria.

The monitoring and management of scrub will continue after the BOOM project term as part of the winter work parties which are delivered every year by Butterfly Conservation, Natural England and other project partners.

4. Community Engagement Objectives

All of the DOB project activities were supported by volunteers with different levels of species' knowledge and experience. Volunteers were drawn from several organisations/institutions including Rusland Horizons, students from the University of Cumbria and prisoners from HMP Haverigg but local members of the public, with no affiliation, also contributed their time as volunteers. Some activities, such as propagating and planting cowslips, required minimal training and were suitable for most volunteers with a reasonable level of fitness. Other more technical tasks such as captive breeding required a high level of dexterity, knowledge and skill and were undertaken by a small number of highly motivated and trained volunteers. Volunteers were provided with training through online webinars, field briefings and written resources produced by the BOOM project officers such as the Captive Breeding Handbook and the Protocol for Adult DOB Timed Counts.

Many activities such as surveys and winter work parties were implemented jointly by volunteers from BOOM and Butterfly Conservation. This collaboration was mutually beneficial with opportunities for BOOM volunteers to learn from lepidopterists with species specific expertise in return for volunteering time.

Recommendations

BOOM is recommending that the DOB project volunteers contribute their knowledge and skills to support the activities of Butterfly Conservation and other landowners at DOB priority sites.

The propagation of larval foodplants at HMP Haverigg was very successful and low cost during the BOOM project term. It is recommended that project partners liaise with the prison to develop longer term arrangements for the propagation of cowslips and primroses which will contribute to prisoner well-being and provide stock for habitat restoration work.

4. Research

Yasmin AliEskandari, a graduate from the Conservation Programme at the University of Cumbria, studied genetic diversity in local populations of DOB around Morecambe Bay. She extracted DNA from pupal cases and planned to use PCR methods to amplify sequences of DNA. Her methods were robust, but the results were inconclusive.

It is recommended that staff at the University of Cumbria collaborate with Butterfly Conservation to create additional opportunities for undergraduate or masters level dissertation to undertake research on the genetic diversity of DOB populations at the two main sites in the Rusland Valley and Whitbarrow NNR.

5. Conclusions and Summary

The BOOM DOB project was developed with ambitious ecological aims to expand the metapopulation structure for this species by using captive breeding methods to populate new colonies in areas of suitable habitat. This goal was unachievable in the term of the BOOM project due to the small size of donor populations along Morecambe Bay and substantial fluctuations in breeding performance from year to year. No eggs were harvested from the potential donor site on Whitbarrow NNR and the number of overwintered pupae from Broadsyke in the Rusland Valley from egg/larvae harvesting in 2021 and 2022 was deemed insufficient to form the basis of a new satellite colony. Despite these limitations, the captive breeding of DOB resulted in a population reinforcement over two years at Broadsyke and helped to build volunteer capacity for future captive breeding work.

Habitat and DOB population surveys were implemented at potential donor and recipient sites for three years (2021/22/23) and constitute an important dataset which describes trends in species abundance and range. Data has been shared with partner organisations (BC/NE) and can be used to prioritize conservation interventions for DOB in the future. Of all the project activities, the propagation and planting out of cowslips and management of habitat during winter work parties had the greatest potential for community engagement. These habitat-based activities also helped to build lasting relationships with partners such as BC to secure the legacy of the BOOM DOB project.

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