

REPORT

# Narrow-headed Ant *Formica exsecta* Captive queen rearing, mating and release 2020

Betsy Vulliamy



Saving the small things that run the planet







Back from the Brink species recovery project for the Narrow-headed Ant, *Formica exsecta*. Captive queen rearing, mating and release 2020



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## Introduction

The Narrow-headed ant (*Formica exsecta*) in Britain is confined to the Caledonian forests of the Spey Valley in the Scottish Highlands and to a single Devon Heath in Southern England. It has been in decline in the UK since the 1950s. It was once present in the lowland Heaths of Dorset, the New Forest, The Isle of Wight and North Cornwall but in the 1980s the last Cornish site was lost and only four sites in Devon remained. It was then lost from Bovey Great Plantation and Lustleigh Cleave due to changes in habitat management. The final nest was seen at Bovey Heathfield in 2004 where its decline was possibly due to recreational use by trail bikes. This left the Devon Wildlife Trust managed site, Chudleigh Knighton Heath (SX 838 770) as the sole remaining site in England.

The Buglife, Back from the Brink species recovery project, supported by Devon Wildlife Trust and Natural England have been working since summer 2017 to try to further protect this species. The hope is to return the species to Bovey Heathfield where the habitat has now been restored and to increase its range in the Bovey Basin to other local reserves.

In 2019 initial attempts were made to move whole nests of *Formica exsecta*, firstly to the edges of its present site and then to nearby reserves. These are mentioned below but described in detail in (Walters, 2019) (Walters, 2018).

This report describes work done in 2020 to try to further increase the range of *Formica exsecta* by captive rearing, mating and release of queens and by introduction of queens to artificially split "queenless" nests.

### **Previous nest translocations**

#### Whole nests

Whole nests were moved initially using a digger but after the first two, bucket and wheelbarrow were used, see (Walters, 2018). The second method seemed to have a lower impact on both the nest and the field site.

In 2018, 6 complete nests were translocated within Chudleigh Knighton Heath in July and November. Another 3 were moved to Bovey Heathfield where the Narrow-Headed ant had not been seen since 2004. Two more nests were taken into captivity by Stephen Carroll (nest 30, 10/12/2018) and Betsy Vulliamy (nest 53, 21/01/2019) for further observation and to attempt to encourage queen production by supplementary feeding. Both captive nests were still active by September 2020. Nest 30 (SC) has remained active since translocation. Eggs were seen in spring 2019 but no queens or pupae have been seen at any point. Nest 53 (BV) produced winged males in both July 2019 and July 2020. Workers were active each spring but appeared inactive in winter. No worker pupae or teneral workers were ever seen. Further notes on both captive nests are given in Appendix 2.

In 2019 another two complete nests were translocated to Teigngrace Meadow Nature Reserve where *Formica exsecta* have never been present. All translocations are listed in Table below.

#### **Queenless nests**

'Queenless nests' were also created in 2019 and 2020 on both Bovey Heathfield and Teigngrace Meadow in 2019 and 2020. This was done using the method devised by John Walters and described in (Walters, 2019).

A proportion of workers, brood and nesting material were taken from an existing nest and placed in a prepared *Molinia caerulea* tussock on the new site. The tussock was prepared by creating a cavity

in the centre and placing a tile and thatching material (chopped grass) on top. If there was not a suitable tussock available on site, then one was also translocated from Chudleigh Knighton. Donor nests with brood were used in the hope that this would give the workers a common purpose and keep them together as a "nest".

So far, the success of these partial nest translocations is not completely clear. Some nests appear to have become inactive. In some cases, this may mean the ants have died but in some, ants may have moved to another location or may not have been inspected in suitable conditions. Due to the COVID 19 lockdown from March 2020 it was not possible to monitor these nests as thoroughly as planned in spring so they may be more successful than was observed.

All complete or partial translocation attempts since 2017 are shown below in Table, Further detail of work done at Bovey Heathfield is described in (Walters, 2020).

FULL NEST TR	ANSIOCATIO		nests were taken from Chudlei	ah Knighton	Compartment	8		
Nectoumber	Dete	Voor	To	A etine 2018	Active 2010	Active 2020	Broad span	Other peter
Nest number	Date	Year		Active 2018	Active 2019	Active 2020	Brood seen	Other hotes
86	July	2018	Comp't 5 Chudleigh Knighton	September	Throughout	active October 2020	2019	Self relocated 3m twice, 2018 and 2019
87	July	2018	Comp't 5 Chudleigh Knighton		April	None seen	2019	Self relocated 100cm in 2018
1	November	2018	Comp't 1 Chudleigh Knighton	December	Until April	None seen	15/04/2019	
40b	November	2018	Comp't 1 Chudleigh Knighton	December	Until April	None seen		Flooded twice November 2018-Feb 2019
13	November	2018	Comp't 3 Chudleigh Knighton	November	Until April	None seen		
98	November	2018	Comp't 3 Chudleigh Knighton	December	Until April	None seen		
134	November	2018	Bovey Heathfield	December	Throughout	Throughout until 15/07/2020	Brood 04/05/2020, Cocoons, 22/05/2020.Male 19/06/2020	Suddenly quiet after 15th July
139	November	2018	Bovey Heathfield	December	(notes)	None seen	2019	Lasius niger took original nest but
								F.execta relocated to nearby tile spring 2019
17	November	2018	Bovey Heathfield	December	Throughout	Low activity?	2019	
68	December	2018	Captivity SC	December	Throughout	Throughout	Eggs 2019	
53	Jan	2019	Captivity BV	NA	Until October	Until July (nuptial flight)	Allate brood and winged males	No worker brood.
	10000							Winged males produced (see appendix 3)
194 (T2)	18 November	2019	Teigngrace Meadow	NA	November	Inactive spring 2020		
198 (T3)	12 November	2019	Teigngrace Meadow	NA	November	Throughout	2020	Move fimed by "The One Show"
QUEENLESS N	ESTS (Workers	and br	ood moved into new tussock a	nd mated que	eens offered la	ter)		
Nest number	Month	Year	То	Active 2018	Active 2019	Active 2020	Brood seen	Other notes
Donor 5	June/July	2019	Bovey Heathfield	NA		Males		
Donor 7	June/July	2019	Bovey Heathfield	NA		Little		3 mated queens released nearby in July 2019
Donor 8	June/July	2019	Bovey Heathfield	NA		Little		Extra workers added August 2019
Donor 165	November	2019	Bovey Heathfield	NA		Active		
Donor 23 (T1)	1 July	2019	Teigngrace Meadow	NA		One ant seen in 10th July		Moved from original tussock of soft rush
						but no sign since		to mossy soil below Birch tree
Donor 26	13 May	2020	Bovey Heathfield	NA	NA	Active	Cocoons 22/5/2020, 19/6/2020 May. Male 30th June	Extra workers added 19/05/2020
Donor 6	2		Bovey Heathfield		0	Males		
Donor 179	13 May	2020	Bovey Heathfield	NA	NA	Active		Extra workers added 19/05 and 15/07/2020
Donor 165 (T4)	June	2020	Teigngrace Meadow		NA	Still very active all summer		
Donor 41 (T5)	lune	2020	Teigngrace Meadow	9.	NA	Active until August 2020 then	Winged males came with nest	Extra workers added August 2020
Donor 195a	July	2020	Captivity (BV)	NA	NA	Active	Coccoons and teneral workers sent 2020	Worker brood

## Table 1. All translocated nests since 2017 including partial "queenless" nests, near which queens were released later in the season.

#### Success of previous translocation attempts

Two translocated whole nests are thought to have survived more than one season in the wild. These are nest 86, moved to compartment 8 in July 2018 and nest 17 which was moved to Bovey Heathfield in December 2018. Nest 17 was active, and brood was seen in its first year (2019) but in 2020 activity was very low and no brood was seen. These nests have survived almost 2 years since being moved.

The other complete nest still surviving now in the wild is T3 in Teigngrace Meadow which was translocated in November 2019 so has now lasted 11 months and is thriving (Photograph 1). This nest has been fed at least once a month all year (AR), which may well have contributed to its success. The two captive complete nests have survived for almost two years but have been sheltered and fed throughout. Overall 2 of 11 complete nest translocations is known to have survived 2 years in the wild and one has survived one year.

The first 'Queenless nests' were created at Bovey Heathfield in July 2019 by John Walters. A few queens were released near these nests later in summer 2019 (SC) and more in summer 2020 (JW,BV). So far, they are all still active in July 2020. However, it won't be possible to fully assess their success until they are seen to produce their own brood which might be in spring 2021.

Although we don't yet know the full success rate of this method of translocation, queenless nest creation has a much lower impact on the donor site than the removal of complete nests. It does not risk losing the original nest. This would probably be the preferred method for any future work. By spring 2021 it should be possible to see whether these nests are producing new workers and are therefore able to maintain themselves. If so then further nests could be created by this method.



Photograph 1. Nest T3.

This complete nest was moved to Teigngrace meadow in November 2019. It has produced brood and winged males and is still thriving (October 2020). NB the ants have made a thatch using small fragments of heather, hence the reddish colour, rather than the fragments of *Molinia caerulea* normally used.

## Captive mating and release project 2020

A team of people was involved in this project in 2020. They are listed below and will be mentioned using initials throughout this report.

Stephen Carroll (SC), Buglife, Narrow-headed Ant Back From The Brink Project Officer, Mark Bailey (MB), local volunteer, Andrew Bakere (AB), Devon Wildlife Trust reserve manager for Chudleigh Knighton Heath, Andrew Ross (AR), local volunteer, Betsy Vulliamy (BV), Buglife volunteer and Ecologist, John Walters (JW), volunteer and Consultant Ecologist.

#### **Queenless nests at Teigngrace Meadow**

On 30<sup>th</sup> June 2020 two new queenless nests were created at Teigngrace Meadow as mentioned above. For each nest, a tussock of *Molinia caerulea* was transplanted to Teigngrace Meadow as there were few suitable tussocks already present. There is *Molinia caerulea* on the site but not in large tussocks. As *Formica exsecta* nests are not always in *Molinia* and as most of their other requirements are present on the reserve, Teigngrace was still seen as a suitable site for introduction.

Buglife, Back from the Brink species recovery project for the Narrow-headed Ant, *Formica exsecta*. Captive queen rearing, mating and release 2020. Betsy Vulliamy



Photograph 2. a) Releasing ants from donor nest into new 'Queenless nest' T4, at Teigngrace Meadow Reserve and b) ants feeding on honey and egg mixture.

Nest 165 was used as a donor to create T4 and nest 41, to create T5. The nests were fed with fruit, honey and egg mixture and fly based fish food (Fluval, Bug Bites, Goldfish Formula) every few days for the first two weeks and then less frequently (BV, AR, Photograph). The *Molinia* tussock was also watered during hot weather. Nest T5 (41) was topped up with extra workers on 30<sup>th</sup> July 2020. Nest 165 had by then been damaged by cows and was not looking healthy, so no more workers were taken from this one and T4 was not topped up. Donor nests were also given supplementary food during site visits over the following week (Photograph 3).



Photograph 3. Feeding donor nest 41 pear and apricot after removing ants.

Nest T4 appeared settled within a few days but workers at nest T5 appeared more defensive. Also, two winged males appeared from T5 which had not been noticed on collection from the donor nest. Four mated queens were released near these nests at Teigngrace Meadow on 14<sup>th</sup> and 16<sup>th</sup> July. By mid-August 2020 no ants were seen at T5 but T4 was still doing well.

#### Captive "Queenless" nest

On 6<sup>th</sup> July a queenless nest with worker brood but no alate brood (winged adult brood), from donor 195a was taken into captivity (BV). The nest was kept in a plastic box with 'fluon' painted around the top edge to prevent escape. The box was kept in a partially open greenhouse It was sprayed with water every 3-4 days or more in hot weather and fed with honey and fish food. Two mated queens from nest 55 were added to this nest on 14<sup>th</sup> July 2020. The nest was still thriving on 21<sup>st</sup> August. On 19<sup>th</sup> August on a cool but sunny afternoon worker cocoons were seen under the tile.

On 7<sup>th</sup> of September there were still lots of worker cocoons as well as lots of teneral (newly hatched) workers. The workers looked smaller than usual and could have either been from eggs brought with the original nest or possibly from new eggs laid by an introduced queen. By 10<sup>th</sup> October ants were still seen but were becoming less active, as is often seen during autumn and winter. When a heat light was placed above the nest for an hour on 4<sup>th</sup> November 2020 the workers became active. This nest will be kept until spring 2021 and then if it produces new brood this will show that an introduced queen was accepted, and the nest can be translocated to Bovey Heathfield.



Photograph 4. Captive 'Queenless nest'. Created in July 2020, Queen added 14<sup>th</sup> July. Worker numbers have increased, and they were still active in November 2020. Kept In plastic box with 'fluon' to prevent escape.

#### Survey of nests producing winged adults (alates)

Since August 2018, the majority of *Formica exsecta* nests on Chudleigh Knighton Heath have been mapped, marked and monitored by Steven Carroll, John Walters, Betsy Vulliamy, Andrew Ross, Mark Bailey, Christine Whittle and other occasional volunteers.

Small (4cm x 4cm) tiles of roofing felt have been placed within the thatch on top of each nest (method devised by JW). These tiles can be gently lifted so that in the correct weather conditions the brood can be observed with little disturbance to the nest. The worker ants move the brood around to keep it at optimum temperature. On cool but sunny mornings the thatched solarium and the felt tile collect the sun's warmth, so the brood is often brought to the top of the nest and can be inspected (Photograph 5).



Photograph 5. Felt tile, lifted to show a) pupae and worker ants and b) pupae and larvae.

Pupae were visible in cooler weather from 4<sup>th</sup> June (JW). Alate pupae can be distinguished from worker pupae by their size and colour (Photograph). From the end of June, the nests were checked regularly for the presence of alate cocoons (MB, BV, JW). Brood (eggs, larvae and cocoons) was seen from 11<sup>th</sup> May (MB) and alate cocoons from 6<sup>th</sup> June onwards (MB, BV). As many as possible of these known alate nests were then monitored more frequently for hatching queens and males (Photograph 7).



Photograph 6. a) Felt tile on top of nest is lifted exposing both alate (*e.g.* red arrow) and worker cocoons. b) worker cocoons (blue arrow) and eggs.



Photograph 7. Felt tile has been lifted to show winged males basking. They will wait near the top of the nest until they are mature, and conditions are right for nuptial flight. This can be 2-3 weeks (Personal observation).

Any nests with queens were mapped carefully and marked with purple wool so that they could easily be found again for observation of the nuptial flights and collecting of queens for mating (Map 1). They were also given slightly larger felt tiles in the hope that this would make capture of queens easier. The first winged males were seen on 24<sup>th</sup> June and the first queens 11 days later on 6<sup>th</sup> July. This was earlier than in 2019 when the first new winged queen and male ants were seen on 16<sup>th</sup> July.

The total number of nests producing alates is unknown as it was not possible to inspect all the nests during the correct weather conditions. However, 49 nests were confirmed to contain alate cocoons. Of these, 33 were later seen with winged adults, 12 of which produced queens and 28 of which produced males (Table 2). 7 of these nests contained both males and queens. With more people to perform surveys when the brood was near the surface it seems probable that more nests would be found producing males and queens.

Table 2. All 29 nests found with alate cocoons and the % of these producing winged adults. See appendix for full list of nests. NB percentages are of the total number of alate nests recorded and 7 produced both males

All nests where alate cocoons were seen		
	Total number found	% of alate nests
Alate cocoons	49	
Winged queens	12	24%
Winged males	28	57%
Both males and queens	7	14%
Unknown	16	33%

and queens.



Map 1. Chudleigh Knighton Heath. Showing all nests which were seen to produce winged males or queens in 2020. Further nests were known to have alate cocoons but were not surveyed at the right conditions to see winged adults.

#### **Nuptial Flights on Chudleigh Knighton**



Photograph 8. Queen Narrow Headed Ant climbing grass stem close to the nest until enough height is gained for flight.

In 2019 Queens and males were seen climbing grass stems and flying on the 22<sup>nd</sup> and 23<sup>rd</sup> July (SC).

In 2020 the nuptial flights began 10 days earlier. The first males were seen flying at nest 59b on 12<sup>th</sup> July 2020 from 08:30 until 09:30. Queens were seen shortly afterwards at nest 31. After this the site was visited around every other day until 30<sup>th</sup> July when there were still queens emerging. The nuptial flights continued in sunny weather for at least 18 days.

Nuptial flights were observed by BV on 12<sup>th</sup>, 17<sup>th</sup>, 18<sup>th</sup>, 20<sup>th</sup>, 21<sup>st</sup>, 22<sup>nd</sup>, 26<sup>th</sup> and 30<sup>th</sup> July. Notes were made but most time was spent collecting winged adults. After the 30<sup>th</sup> July, alates may have continued to emerge but no further site visits were made.

Emergence began on warm days whenever the sun first hit the top of the nests, usually after 07:30. Both males and queens would appear under the felt tile or on top of the nest and workers would be active and climb grass stems around the edges of the nest. As the day warmed up the males and queens would also climb grass stems and start to fly when sufficient height was gained (Photograph 8). Often, several attempts were made at flight. This tended to carry on whilst it remained sunny but was always over by around midday. Occasionally a queen or male was seen to return inside the nest.



Photograph 9. a) Queens and b) male, emerging from nests and preparing for flight.

#### Collection of winged adults for captive mating

#### 1. Collection of winged adults during nuptial flights

Alates were collected as they climbed grass stems around the nest (Photograph 9). They were taken in jam jars with net inserted in the lids to avoid build-up of formic acid fumes (Photograph 10). As often as possible, workers and a small amount of nest material were taken along with the winged adults so that the alates had workers to look after them. Jam jars were kept at room temperature in shade or dark until captive mating attempts usually the following morning. A damp sponge for water and a piece of apple to provide sugar was added to each jar.



Photograph 10. Jam jars used for collection of winged adults and workers.

#### 2. Collection of winged adults from under tiles

A single attempt was made removing one queen from nest 12 when basking under the felt tile along with some workers and nest material in a jam-jar as above. She was brought straight home and matings attempted using males from the captive nest (53) as detailed below.

#### 3. Hatching winged adults from 'Mini-nests'

On 10<sup>th</sup> July 2020 at 10:45 three 'Mini-nests' were taken from Chudleigh Knighton from nests 31, 39 and 5a. A small jam-jar of nesting material and workers were taken from the side of each nest and brood and winged adults were taken from under the felt tile. Jars had net sections in the lids to reduce the risk of ants suffocating themselves with formic acid.

These 'Mini-nests' were set up at home in either net cages or glass tanks by putting a layer of loose soil at the bottom then a wreath of grass, to create a cavity and a tile on top. Brood was poured into the cavity and extra nesting material put round the sides (Photograph 11). Vertical grasses and plant stems were added to allow alates to climb. Each nest was sprayed daily with water and was given a damp sponge for water, as well as honey or fruit and bug bites fish food. Food was changed regularly to avoid mould.

The nests were kept on a sunny windowsill but were also put under a heat lamp if it had been cloudy for a while to ensure that alates and brood had enough heat to mature.

The nests were inspected daily and over the following days more queens appeared under the tiles. Heat lamps were shone on the nests from 7 am every other morning. If queens or males emerged from the nest and began climbing the walls or stems, they were assumed to be mature enough to attempt nuptial flights. They were then either removed and included in captive matings as described in setup a) below or else the whole 'Mini-nest' was included in a mating cage as in setup c) below. All 'Mini-nests' produced new queens but they usually returned to the nests at night. This meant it was not possible to keep count of the total number. Workers in Mini nest 5a had died by 21<sup>st</sup> August 2020 but it was not clear why.

Further 'Mini-nests' were created from nests 27 and 100. Details are shown in Table 3.



Photograph 11.1 a) Ring of grass to create cavity for 'Mini-nest'. b) Complete 'Mini-nest' with nesting material and ants added and tile for cover.

#### **Captive mating**

#### Setup A)

- 1. Males and queens from different nests captured on site or after emerging from captive nests.
- 2. No workers present in mating cage.

Mating tanks were set up based on methods developed in 1997 (Perrett, 2019).

A glass tank (25cm x 45cm) or net cage (40cm x 60cm) was set up containing nest material for shelter, a damp sponge to provide water and fruit or honey for sugar. (Males were observed feeding on honey solution).

Fresh grass stems and leafy twigs were placed in one corner for each mating attempt.

On either the evening previous to mating or very early the same morning Males and queens were brought from the field site or from other captive nests and added to the cage. A heat lamp (Arcadia Reptile Solar Basking Spot Lamp) was placed above the tank in the same corner as the twigs and turned on from 7 a.m.

The initial glass tank used didn't give enough height for the twigs and for the ants to climb. There were also problems with condensation so after the first two attempts, 40cm x 60cm net cages were used instead (Photograph 12).



Photograph 12. Left: Setup B), Net cage with fresh twigs, damp sponge, fruit and nesting material. Right: Winged *Formica exsecta* climbing to corner closest to heat lamp.

#### Setup B)

- 3. Queens from one nest and males from different nests captured on site.
- 4. Workers and nest material brought from same nest as queens also added to mating tank.

The same basic set up was used as in a) but in order to give the queens a better chance the workers and nest material brought from their own nest were put into the mating tank with them. It was then observed that workers meeting a queen would join mandibles, presumably feeding her. On one occasion a wingless queen appeared to be feeding a winged queen. Both the queens and the males (from a different nest) would return to the nesting material with the workers when the lamps were turned off. Workers were seen grooming the queens. After the queens were mated and ready to release in the field, the workers were returned to their original nest.

#### Setup C)

- 1. Mature queens emerging from 'Mini-nest' within mating cage.
- 2. Males added from jars brought from different nests on field site or from different captive nest.
- 3. Workers, brood and immature alates from same nest as queen present in 'Mini-nest' within mating cage.

The same basic setup was used as for "B" but a whole 'Mini-nest' was put inside the large insect net (Photograph 13). Males were added. These were from the jars of captured alates caught on site or occasionally from other captive nests. Queens from the Mini nest could then either leave the nest and mate if they were ready or stay inside. If they were not caught and released on field sites, both queens and males always returned to the nest after mating. If queens were still out of the nest after midday, workers often picked them up and carried them back to the nest (Photograph 14).

Setup B and C made it harder to keep track of which queens had mated but allowed them to be kept in captivity for longer and have repeated mating attempts. The males were also fed by workers so could presumably live longer. Workers were observed feeding males who were not from their own nest. As it was not always possible to tell added males from newly hatched males, males were frequently moved between mating cages to reduce the chance of sibling matings.





Photograph 13. Setup C) whole 'Mini-nest' placed inside larger mating cage and males added to allow queens to leave the nest or return as they choose.



Photograph 14. Workers in mating cage carrying queens back to 'Mini-nest' after midday.

#### **Observation of mating**

#### Mating attempt 1

The first captive mating was trialled on 7<sup>th</sup> July which was 5 days before the nuptial flights had begun. A single queen and workers were taken from under the felt tile in nest 12. A heat lamp shone on the already captive nest (BV) from 7:30, triggered males to leave the nest within an hour. Four males were caught at 10am then the lamp was turned off.

At 10:15 the queen and males were released into a mating tank. Detailed notes were made and are included as Appendix. Overall, the males were very active, yet the queen showed no interest at all. She moved around the floor but did not climb. This was repeated at 7am the next morning and as the queen still showed no interest it was assumed that she was teneral (newly hatched) and not mature enough for mating.

The queen was returned to her original nest (12) at Chudleigh Knighton. 3 males were released nearby. The fourth male died.

#### Mating attempt 2

On 12<sup>th</sup> July 2020 nuptial flights began at Chudleigh Knighton and males and queens were captured as they left their nests. They were taken in jam jars with some workers and nest material from the same nest. Either males or queens were collected from any one nest. According to previous work mating does not occur after midday even if the first sun to hit the nest is later (Perrett, 2019) (AntWiki, 2020). However, the mating tanks were set up anyway to allow the ants to become used to them and in order to observe their behaviour.

At 12:20 a mating tank was set up with 2 queens from 55 and males from 5a. Detailed notes were made and are shown in Appendix . Queens took some time to settle but after a while interacted with males and formed 3 pairs. Preening was observed but no mating (Photograph 15). The males seemed to lie across the females maybe "guarding" them. They also appeared to be chewing the

base of the queen's wings and one queen was later observed to have tiny holes in her wings. At 15:00 the lamps were turned off, but the ants remained in their pairs. Cages were left as they were overnight and the next morning lamps were turned on from 7am but not observed as I needed to be on site collecting more winged adults.



Photograph 15. Male *Formica exsecta* preening or guarding queen at base of glass tank.

#### **Further mating observations**

On 14<sup>th</sup> July males and queens were arranged in tanks at 7am and at 7:30 lamps were turned on. Alates immediately began flying around the cage, climbing and grooming one another.

Queens spent a lot of time grooming the tips of their own abdomens (Photograph 16b). This may have been cleaning, removing or possibly releasing pheromones. Sometimes this appeared to be post coital, but the behaviour was also observed when no mating had been seen.



Photograph 16 a) *Formica exsecta* mating. Lasting about 20 seconds. b) Queen *Formica exsecta* (on left) cleaning tip of abdomen after mating; male (on right) just after mating.

First mating was observed at 09:07 between male 41 and queen 31 in the corner of the tank nearest the heat lamp (Photograph 16a). Mating lasted around 20 seconds followed by abdomen cleaning by the queen (Photograph 16b). The male stayed within 2 cm and mating was repeated at 09:11 and 09:18. The queen seemed to allow mating for about 20-35 seconds then to push the male away with her head (Appendix 6).

Notes were taken on all mating attempts but are not all detailed here. General observations were that most mating took place between 07:30 and 09:30 but carried on until about 12:00. Occasionally another mating was seen later, once at 14:00.

There was often a lot of preening and grooming between a pair before mating (Photograph 17) and mating was sometimes never seen though it was difficult to watch several cages at once so it could have been missed. Mating usually took place high up and as near as possible to the heat lamp. The same pair would mate for 10 to 35 seconds and would mate several times, a few minutes apart. By 11:30 or 12 most ants would have settled, often on the bottom of the cage or on sponges or nest material. They often remained in male female pairs. This could have been males "guarding" females. It is possible that some of the coupling seen was not true mating but where coupling was seen the ants were "presumed mated".

Although it was not measurable, matings seemed to be seen more frequently when the ants had been in a cage together for most of the previous day along with their 'Mini-nests'.

Mating attempts were repeated every one or two days and alates were released on site whenever they had had at least two chances to mate. This was continued until there was only one queen left in each 'Mini-nest' (Table 3 on p.19).



Photograph 17. Grooming behaviour. This would take place repeatedly and may or may not be eventually followed by mating. On this particular occasion (snapshots 5 and 6) the male and queen seemed to join mandibles and tickle one another with their antennae for around 15 seconds.

#### Ongoing maintenance of 'Mini-nests'.

After nuptial flights were over, one queen was kept in each "Mini" nest in the hope of setting up a nest which could later be translocated to a new site. After 21<sup>st</sup> August, heat lamps were shone on each nest for an hour every few days before inspection to encourage basking and to allow observation of what was under the tile.

Nests in glass tanks needed more regular maintenance because of condensation, causing mould.

On 16<sup>th</sup> July a wingless queen from nest 27a was mated. As she seemed less likely to succeed in starting a new wild nest without wings, she was kept, and a new "Mini" nest created with workers and brood from 27a.



Photograph 182. Wingless queen from nest 27a, now in captive 'Mini-nest' 27a.

Table 3. 'Mini-nests' created and changes made through August and September.								
Nest number	Donor nest 31	Donor nest 39	Donor nest 5a	Donor nest 27a	Donor nest 100			
Date collected	18/07/2020	10/07/2020	10/07/2020	16/7/20	20/07/2020			
Adult queens collected	1 winged queen	1 winged queen	1 winged queen	1 wingless queen	1 winged queen			
Adult males collected			3 winged males					
Workers	Workers	Workers	Workers	Workers	Workers			
Brood	Worker and alate cocoons	Worker and alate cocoons and larvae	Worker and alate cocoons	Worker and alate cocoons	Worker and alate cocoons			
New queens produced	Yes	Yes	Yes	Yes	Yes			
Status on 21/8/2020 when nests were completely dismantled and rebuilt.	Few workers and one worker cocoon. Queen not found.	Scrumple-winged queen. Plenty of workers. Worker cocoons.	NA This nest died. No workers survived so queen 5a was released.	1 Wingless queen. No brood.	1 Winged queen. No brood. Made tunnels inside flower arranging "oasis".			
Status on 28/08/2020		Lots of workers and worker cocoons						
09/09/2020					Lots of workers			
17/09/2020	Worker cocoons	Queen running around cage. Teneral workers.		Active	Very active			
19/09.2020		Offered tussock grass in pot.						
20/09/2020		Moved into ceramic flowerpot with parsley plant		Offered pre- prepared Molinia tussock	Offered pre-prepared Molinia tussock			
22/09/2020	Workers present	Workers present		Workers present	Workers present. Whole nest has moved into Molinia tussock			
24/09/2020	Offered pre- prepared Molinia tussock	Offered pre- prepared Molinia tussock		Remaining in original nest	Look settled in Molinia tussock			
26/09/2020	Still in original nest. 1 worker cocoon seen under tile.	Nest has moved to new tussock.		Remaining in original nest	Still in new tussock but moved back to oasis in tray by 4 <sup>th</sup> November.			

able 3.	'Mini-nests'	created a	and char	nges mad	e through	August a	and September	
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On 20<sup>th</sup> of August these nests were dismantled and re-built in compostable trays or baskets to see if they still had queens and to make them easier to move back to the wild once established. The ants in 'Mini-Nest' 27 had made tunnels in a piece of flower arranging oasis (Photograph 19a). Regular checks were made on the nests and from 20<sup>th</sup> to 24<sup>th</sup> September they were all offered pre-prepared tussocks *of Molinia caerulea* in case they chose to move. By 22<sup>nd</sup> September "Mini 100" had moved into the *Molinia* tussock but by 4<sup>th</sup> November they had moved back to a tray of soil and were settled under a piece of "oasis".

On 22<sup>nd</sup> September "Mini 39" had moved into a ceramic flowerpot but by 26/09/2020 this nest had also moved into a tussock. The remaining two nests were offered very small tussocks so will be offered larger ones later in November.



Photograph 19. a). Tunnels made by ants from 100a in "oasis used to support flowers 21/08/2020. b) 'Mini-Nest' 27a after transfer to basket. c) The top layers of 'Mini-Nest' 27a were removed at the end of September and a queen could still be seen in a cavity at the very bottom in a cavity within a piece of oasis which was moved with them.

None of the 'Mini-nests' had visibly produced eggs or brood by 25<sup>th</sup> September 2020 so they will be kept over winter in the hope that they will reproduce in the spring. If successful they will be translocated back to Chudleigh Knighton or Bovey Heathfield. Their current status is shown in Table 3 above.

#### Mated queen release

If a queen had been moving around in a mating cage with unrelated males between 7am and 10am on two mornings she was "presumed mated" even if mating was not seen.

The first two presumed mated queens from nest 55 was introduced to the captive "queenless" nest (BV) on 14<sup>th</sup> July 2020 at 10:30 am They disappeared into the vegetation beside the nest. We will not know whether they were accepted for certain until we see eggs or larvae under the tile. Probably next spring.

On 14<sup>th</sup> July more queens were released at Bovey Heathfield D6 and Teigngrace Meadow T4 and T5. The first two at Bovey and one at Teigngrace disappeared into the vegetation. One went into the side of T5 and hid. The last one was put on top of T4 but appeared to be attacked by workers. It was then carefully separated it from workers and released slightly further away. As we are not sure how new queens approach a nest it was felt that she might be better off finding her own way in.

Further queens were released as shown in Table 4, usually one or two feet from a queenless nest. The final few were released at Dunley Cross, part of Chudleigh Knighton Heath where there are just two nests (174 and 174b, Photograph 21). These were released with food which they were seen using immediately (Photograph 20) and could be a useful method for further releases next year. There have been nests in this area since previous releases of mated queens in the 1990s (Perrett, 2019)



Photograph 20. a) *Formica exsecta* queen feeding on grapes just after release at Dunley Cross, 23/07/2020; b) Release of mated queen from jam jar.



Photograph 21. a) Beautifully thatched example (174) of one of just two *Formica exsecta* nests already present at Dunley Cross. b) Second nest (174b) at Dunley Cross has become overgrown with bramble and has no thatch but is still busy with ants (July 2020).

Date	Time	Queens	Number	Males	number	Release Site	Release near
14/07/2020	11:00	59b	2			Bovey Heathfield	Donor 6
		12	1			Bovey Heathfield	Donor 6
				41,81	2	Bovey Heathfield	Donor 165
		5a	2		1	Teigngrace Meadow	T4(Donor 165)
		5a	1			Teigngrace Meadow	T5(Donor 41)
16/07/2020	07:30	55	1		2	Teigngrace Meadow	T1
18/07/2020		31b	1	59b	3	Bovey Heathfield	Nest 179
		31	2	5a	2	Bovey Heathfield	Nest 179
				41,81,57	4	Bovey Heathfield	Nest 5
20/07/2020	11:00	31and 31b	3	?	2	Bovey Heathfield	Donor 6
		31	2	?	1	Bovey Heathfield	Donor 7
		31and 5a	3	57b	2	Bovey Heathfield	donor 26
23/07/2020		41	2			Bovey Heathfield	Donor 45
		31	1			Bovey Heathfield	Donor 45
		100	2		2	Dunley Cross	174b
		39	3			Dunley Cross	scrub edge 6m from 174
Total number released			26 Queens		21 Males		
			200010				

Table 4. Dates and locations of mated queen releases 2020.

#### Cattle

Cattle were let on to compartment 8 of Chudleigh Knighton Heath on 9<sup>th</sup> July 2020 and their effects were immediately visible. Unfortunately, the cattle were larger and heavier than those on the site in 2019 and their presence coincided almost exactly with the *Formica exsecta* nuptial flight period. The cattle seem to have a taste for the felt tiles used to monitor the ant's nests and so either this, or a liking for ants led them to eat the centres of several nests. On 22<sup>nd</sup> July, the centres of nests 41, 8 and 81 had been eaten along with labels and felt tiles.



Photograph 22. Nest 8 on 22<sup>nd</sup> July. Most of the thatch and the felt tile have been removed along with any brood which may have been under the tile.

Other nests were damaged by trampling and overall the damage caused to the Formica exsecta at their most sensitive time seemed significant. The labelling system was disrupted and as the tiles had been eaten this made monitoring the nests more difficult. As larger tiles had been placed on the nests with queens this may have made them more attractive to cows and so these were some of the worst affected.

Buglife, Back from the Brink species recovery project for the Narrow-headed Ant, *Formica exsecta*. Captive queen rearing, mating and release 2020. Betsy Vulliamy



Photograph 323. a) Cow feeding directly next to *Formica exsecta* nest (John Walters). b) Metal label chewed by cow.

From 16<sup>th</sup> July onwards many tiles were removed from the nests (MB) in the hope of avoiding further damage. The matter was discussed with Stephen Carroll and Andrew Bakere (Devon Wildlife Trust) and it was decided that the worst of the damage had already been done and no further changes could be made this season.

There is an ongoing need for management at Chudleigh Knighton Heath in order to prevent the encroachment of gorse and bracken. The cattle do contribute to this; however, it was noticed that in compartment 8 they remained mainly on the grassy rides, only occasionally straying into the taller vegetation. They had some effect on the bracken, mainly by trampling but very little effect on the gorse which is the main species shading out the ants' nests.

As Chudleigh Knighton is the last stronghold for this species the ongoing management has presumably been working. However small changes could have a big impact and it would be worthwhile to re-assess the current management to be sure that it is always the best way to maintain the site for *Formica exsecta*. For example, it was noted over the three years of the Back from the Brink project, that different cattle had different impacts on the ants' nests. It would probably be beneficial to consider using smaller lighter cattle or putting fewer cows on the site at one time so that their impact is slightly lower. It might also be worth trying grazing with different livestock such as Dartmoor ponies. Ideally, grazers would impact more on the bracken and gorse and less on the ants' nests themselves.

It is essential that in the future cattle are not put onto compartment 8 until after mid-August when most of the delicate brood has hatched and the nuptial flights are over. The main monitoring will also be complete by this time and the tiles can be removed, and labels made secure before cows arrive.

It would also be worth warning those involved in the Narrow-headed Ant project when areas are to be burnt. Small areas could be cleared by hand around the most vulnerable ants' nests so that the fire passes them more quickly.

## **Ongoing and future work**

#### **Captive mating**

Further captive mating could be done with very little impact on the existing Narrow-headed Ant populations. The methods which seem most likely to succeed are:

Add tiles to all larger nests at Chudleigh Knighton and check them regularly on Sunny mornings to ascertain which are producing alates. Collect 'Mini-nests' with workers, nest material and alate brood at the end of June. Place heat lamps over the nests each morning and move males from different cages for mating as queens emerge and choose to leave the nest. Further investigation may make it possible to differentiate between male and queen pupae. In this case, either male or queen pupae could be collected from any one nest.

As well as this, as many males and queens as possible could be collected during nuptial flights and mated in cages. Tall cages with a strong heat lamp above work best but these must be kept for as short a time as possible. There is a possibility that with the right equipment this could be done on site allowing for release immediately after mating.

Queens can be released into apparently suitable sites or close to previously created 'Queenless nests'. Queens should be released close to 'Queenless nests' rather than on them, and all released queens can be left with food to give them energy for a better start. If possible, further observations need to be made in order to find out exactly how a new queen can be accepted into a nest which doesn't yet have one.

#### Artificially created captive nests

So far 4 'Mini-nests' (with their own queens) and one 'Queenless nest' (hopefully with an introduced queen) are still surviving in captivity (BV). If these remain successful and produce brood in spring 2021 then they can be relocated to Bovey Heathfield or to other parts of Chudleigh Knighton. If the 'Queenless nest' is successful, then this will show that it is possible for a nest without a queen to accept a newly mated queen placed nearby.

If these methods do work, then they could be repeated in future years with very little impact on the donor population. The hope would be that with regular feeding and protection ant numbers in captive nests can be built up so that they stand a better chance of survival on re-introduction than do nests created on site.

#### Sites

At Teigngrace Meadow, one nest is thriving and has done for almost a year and one queenless nest has survived since July 2020. However, one full nest and two queenless nests seem to be inactive. The site is very dry and has very little *Molinia caerulea* which is the main plant that nests at Chudleigh Knighton are based within.

It would seem sensible to further monitor the success of the translocations already tried at the Teigngrace Meadow site before attempting any more, and to look in more depth at what the specific requirements are for *Formica exsecta* in Devon. Firstly, ongoing work should concentrate on establishing a stable population at Bovey Heathfield where the habitat it is much more similar to Chudleigh Knighton and where *Formica exsecta* have survived in the past.

#### **Habitat characteristics**

In order to support more releases or translocations of *Formica exsecta* it would be useful to understand in more detail their specific habitat requirements. We have seen during this study that

the aphids on birch trees and gorse are an important food source as well as aphids on other plants earlier in the year. Nectar from a variety of plants such as Alder Buckthorn and Hedge bedstraw is used as well as extra floral nectaries on gorse and small legumes. It seems that these ants are relatively adaptable and should be able to survive on a variety of sites as long as they are not overly disturbed or shaded and are not threatened by competitors such as *Formica rufa*. However, their distribution remains extremely limited.

Within Chudleigh Knighton *Formica exsecta* use a variety of sites, some unexpected. For example, nest 83b, between compartment 8 and compartment 5, thrives in spite of being surrounded by tall bramble and some other nests are completely flat and not in a tussock at all.

The nests on the A38 road verge at Chudleigh Knighton are in a very different habitat from the usual at this site and are not in *Molinia caerulea* tussocks. It may be that there is something else on the verge, for example more flowering herbs, which are allowing them to survive here.



Photograph 24. a) *Formica exsecta* feeding on *Gallium mollugo* on the roadside verge. b) Nest 212 on the verge of the A38. This nest is on very shallow soil on the edge of a tarmac path and is not in a *Molinia caerulea* tussock.

AntWiki suggests that in Europe subterranean aphidea are an important food source for *Formica exsecta* (AntWiki, 2020). It would be useful to further investigate whether this is also an important factor for the Devon ants.

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#### **Bibliography**

#### Works Cited

**AntWiki. 2020.** Formica exsecta. *AntWiki.* [Online] July 2020. https://www.antwiki.org/wiki/Formica\_exsecta.

**Perrett, Julian. 2019.** Narrow Headed Ant, *Formica execta - mating and colony establishment project.* s.l. : Encompass Ecology, for Buglife, 2019.

**Walters, John. 2020.** Narrow Headed Ant, *Formica excecta, Back from the Brink, Buglife Report.* 2020.

**Walters, John. 2019.** Narrow Headed Ant, *Formica exsecta Survey for Buglife-Back from the Brink.* s.l. : Back from The Brink, 2019.

**Walters, John. 2018.** Narrow Headed Ant, *Formica execta, survey for Buglife-Back from the Brink.* s.l. : Buglife-Back from the Brink Project, 2018.

## Appendices

Appendix 1. Survey of nests in June 2020 showing where alate cocoons, winged queens or males were seen.

	Nests where alate cocoons were seen	Winged queens	Winged males	Both	Unknown
	12	Queens	Males	Both	
	41	Queens	Males	Both	
	27a	Queens	Males	Both	
	31b	Queens	Males	Both	
	57b	Queens	Males	Both	
	5a	Queens	Males	Both	
	97h	Queens	Males	Both	
	28	Queens	Wales		
	20	Queens			
	31	Queens			
	39	Queens			
	55	Queens			
	100	Queens			
	8		Males		
	24		Males		
	27		Males		
	38		Males		
	59		Males		
	63		Males		
	103		Males		
	106		Males		
	30a		Males		
	110		Males		
	120		Males		
	120		Males		
	120		Nales		
	164		Males		
	175		Males		
	202		Males		
	100a		Males		
	100b		Males		
	103a		Males		
			Males		
	3		iviales		Unknown
	30				Unknown
	37				Unknown
	43				Unknown
	48				Unknown
	54				Unknown
	69				Unknown
	/8				Unknown
	160				Unknown
	100c				Unknown
	122b				Unknown
	2a				Unknown
	37b				Unknown
	42a				Unknown
Nests with alate brood	49	12	28	7	16
% of alate nests		24.5%	57.1%	14.3%	32.7%

#### Appendix 2. Notes on captive ant nest 30 (Stephen Carroll)

Nest 30 has remained active throughout 2019 and 2020. The nest is in a large 165 litre plastic storage crate 60 x 65 x 43 cm, with top brim escape proofed with Fluon, kept indoors, placed before a south west facing window. In spring 2019 workers were observed sunning or clustering in number on top of the nest when sun hit the nest through the window. Eggs were seen but no other obvious brood that year. To mitigate low levels of solar warmth and natural light, a heat lamp was set up over the nest in 2019. Workers showed constant exploratory behaviour, climbing sides of the crate, and a strong reaction to added nesting material (chopped up dry grass), leading to the area of thatch on top of the nest greatly expanding, from 15cm to 33cm.

From autumn 2019 and throughout winter, 1-2 workers were seen at any one time, and there was similarly low activity in spring 2020, with little climbing of the container sides. From late spring 2020 onwards, slightly increased worker activity has been seen on the nest surface, up to approx. 5-10 workers at any one time, but no clustering, nor in the large numbers seen in 2019 or compared to nests seen in the field. Workers would initially feed at fruit such as apples and pears, and on honey, but latterly have shown little interest in sugar water, honey, peaches, or any other fruit except grapes. For protein, some interest was initially shown in egg and tuna flakes, but this waned. Bloodworms and tubifex fish food seem to be taken, but not readily. Dead invertebrate items found and offered, such as worms, grasshoppers, caterpillars and moths have typically generated a feeding reaction. No eggs or other brood have been seen in 2020.

Ever since first set up of the nest, workers have carried dead, usually smaller, workers to the edges of the container to be discarded, total number of such dead workers must now number some 100-200 over the whole of 2019-2020. This may suggest a turnover in production of workers, though no queen or pupae have been seen under felt tiles. The heat lamp has appeared to influence activity levels; over 2020 different bulb strengths and distances from thatch have been tried, in an effort to achieve ambient temperatures towards  $28^{\circ} - 30^{\circ}$ C, reported to be the temperatures which promote brood production. The current set up is 60W bulb approx. 10cm above the nest thatch.

Appendix 3. Notes on captive ants' nest in greenhouse (BV). January 20129 to November 2020.

Nest 53 was successfully translocated from Chudleigh Knighton on 14<sup>th</sup> January 2019. A tussock like nest was chosen in the hope that the ants would not be too far below ground. It appeared that no ants were lost and no damage at all was done during the translocation. The nest was Installed in corner of Betsy Vulliamy's greenhouse in Milton Abbot, Devon.



The nest and surrounding area were sprayed with water every 3 to 4 days in warm weather. They were fed on honey water, egg, fruit and fly based fish food. A second *Molinia caerulea* tussock was planted next to the nest and this was watered regularly so that plenty of water and moist soil would be available near the nest.

27/1/19. The ants were active on the surface of the nest. There was almost no damage during the move and no casualties have been seen.

11/2/19. The ants are active on the surface whenever the sun comes out. Ants are defending the nest but not building.

24/2/19. Ants are seen feeding on honey water but not very interested in egg. Some *Lasius niger* also present in the greenhouse.

7/3/19. Ants have begun thatching the top of the nest with grass fragments.



2/4/19. Ants were seen using extra floral nectaries on broad bean plant.





1/5/19. Greenhouse covered with white sheet to prevent overheating.

2/5/19. Pupae present under tile at top of nest.

12/5/19. Pupae 10 days old.

22/5/19. Lots of *Lasius niger* present. Some were removed. No ants present under the tile, possibly because of warm weather but active below ground.

6/6/19. Winged males emerged under tile.

14/6/19. Males still waiting under tile.

23/6/19. Males still present.

30/6/19. Males no longer visible. Nothing under the tile. No brood. Maybe beneath ground due to hot weather.

3/7/19. Not thatching but appear when disturbed. Males not visible.

23/7/19. Lasius niger flying but no sign of exsecta. No new brood.

28/7/19. No worker brood seen yet. Could be staying below ground.

29/7/19. Only 2 workers visible even with digging.

5/8/19. Only one ant visible on nest even after investigation by digging into side of nest.

14/8/19. Cavity appeared and What looked like outsides of worker cocoons left in feeding dish. May be something unrelated ?



6/10/19. Saw 3 Formica exsecta again.

The *Formica exsecta* were not seen again after 6/10/19 so were "presumed dead" until spring 2020. However, there were workers present again on 16th March 2020. On April 4<sup>th</sup>, 2020 eggs were seen, alate brood was present in June 2020 and adult males were produced in July 2020.

In spring 2020 an avocado plant covered in scale insects was placed near the captive nest. It was hoped that they might feed on honeydew produced by the insects. However, one ant spent 10 minutes peeling a scale insect off the plant and carried it inside the nest. After this this scale insects were ignored.



Photograph 25. Ant from captive nest peeling scale insect off avocado plant.

Although it would be relatively easy for the ants to escape from their corner of the greenhouse and move around, no ants have ever been seen in other areas of the greenhouse. It is presumed that regular feeding has made it unnecessary for them to forage further afield.

#### Appendix 4. Notes on mating attempt 1

#### 6/7/2020.

17:00: A queen was taken from under the tile at nest 12 along with a handful of nest material and workers and kept in a jam jar overnight with fruit and damp sponge.

7/7/20.

10:00am: Four males were collected from the captive greenhouse nest by shining a heat lamp on them to stimulate flight attempts.

10:15: Queen and males released into glass mating tank.

10:30: Queen hiding. Males very active. Largest male flying.

11:00: Queen exploring tank but males not seeming aware of queen.

11:10: Queen resting on grass stem.

11:15: Male passed female but ran away

11:20: Males shivering/vibrating.

11:31: Male approached female, touched antennae then left and did same to another male.

11:40: Queen staying, "hidden" near nesting material on base of tank.

12:00: Queen returned to jar with workers and lights turned off.

8/7/20:

07:00: Queen returned to mating tank and lights turned on. Observed from 07:00 to 09:00. Queen remained hiding. Males active but showed no interest in queen.

17:00: Queen and workers replaced in nest 12 at Chudleigh Knighton. 3 Males released nearby (one died).

Appendix 5. Notes on mating attempt 2

12/7/20

08:30: Chudleigh Knighton. Collected 3 males from nests 5a and 41, 2 Queens from nest 55 and one queen from nest 31.

12:18: Added 2 queens from 55 and 2 males from 5a to one mating tank.

12:40: All active. Crawling round tank.

13:05, one queen climbing twigs. Second queen hiding.

13:10: Male met queen on twigs but ran away.

13:20: Second queen climbing twigs. First queen resting in top corner of cage near lamp.

13:36: Male on top of queen at base of tank.

13:43: Male and queen preening each other.

13:45: Male on top of queen then sitting side by side near nesting material.

14:23: Male lying on top of queen again.

14:26: Male and queen preening each other.

14:28: Second male and queen met. Face to face preening.

15:20: Added queen from nest 31 and male from 41 to a second mating cage.

16:00: Turned out lights and left overnight.

13/7/20. 07:00. Heat lamps turned on, but no observations made as I was back on site.

Appendix 6. Notes on mating attempt 3

13/7/20: New alates collected from Chudleigh Knighton and from 'Mini-nests'.

14/7/20:

07:00: Alates added to mating cages. 4 Queens from 31, 12, 59b and 27a. 4 males from 41.

07:30: All very active, flying, climbing and grooming in male/female pairs.

08:30: 2 queens at top of cage. Appear to be cleaning tips of own abdomens repeatedly. (Possibly releasing pheromones?).

09:07: Queen 31 mated male 41 for 20 seconds in top of cage, corner nearest to heat lamp. Joined by abdomen tips, queen on net ceiling of cage and male dangling by his abdomen. Post coitally queen cleaned abdomen tip again.

09:11: 20 seconds mating again then queen pushed male away with her head.

09:18: 35 seconds mating.

Queens 12, 59b and 27a met and greeted at various times. Touched antennae, no aggression.