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Monitoring invertebrates by pitfall trapping after excavation of the surface vegetation in two slacks at Newborough Warren – Ynys Llanddwyn SSSI in 2013

RG Loxton

NRW Evidence Report No. 22

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1. Crynodeb Gweithredol

Fel rhan o'r gwaith i adfywiogi twyni Tywyn Niwbwrch, cafodd y llystyfiant ar wyneb tri o bantiau gwlyb (llaciau) ei grafu nes cyrraedd tywod noeth a'i osod ar y twyni sy'n ffinio â'r pantiau, a hynny ym mis Mawrth 2013. Ymhellach, cafodd llystyfiant y twyni ei symud ymaith o amgylch y pantiau gwlyb hyn. Mae modd gweld y llecynnau a gafodd eu trin yn y fath fodd mewn awyrluniau yn yr adroddiad. Defnyddiwyd trapiau i ddal a monitro creaduriaid di-asgwrn-cefn, a chanolbwyntiodd y gwaith hwn ar y ddwy gloddfa sydd bellaf i'r tir, gan ddefnyddio pant gwlyb cyfagos fel cymhariaeth safonol. Ni chafodd y gloddfa a oedd agosaf at y môr ei monitro oherwydd rhesymau logistaidd. Aethpwyd ati i drapio'r creaduriaid di-asgwrn-cefn rhwng 3 Mai ac 8 Hydref, ac roedd yn cynnwys cyfanswm o 5465 o nosweithiau trapio effeithiol ar draws 17 o safleoedd samplo. Cafodd Coleoptera (chwilod) Orthoptera (ceiliogod rhedyn a'u tebyg) Diplopoda (nadroedd miltroed), Chilopoda (nadroedd cantroed), Isopoda (pryfed lludw), Araneae (corynnod) ac Opiliones (pryfed medi) eu henwi a'u cyfrif. Cafwyd set ddata o 298 o rywogaethau a 12,838 o greaduriaid di-asgwrn-cefn unigol. Er y bydd y cloddio wedi arwain at golli'r rhan fwyaf o'r rhywogaethau sefydlog, cafwyd tystiolaeth bod pum math o chwilen sy'n nodweddiadol o gynefin llaciau arloesol – yn cynnwys y chwilod daear *Bembidion pallidipenne* a *Dyschirius politus*, y chwilod crwydr *Bledius subniger* a *Gabrius osseticus*, a'r chwilen ddŵr *Dryops nitidulus* – wedi cytrefu yn y pantiau gwlyb a gloddiwyd. Mewn arolygon blaenorol, ni chofnodwyd nifer o rywogaethau – er enghraifft *B. pallidipenne*, *B. bruxellense*, *Helophorus alternans* a *Hydroglyphus geminus* – yn y pantiau gwlyb.

Am y tro cyntaf, cofnodwyd tair rhywogaeth ar ddeg (un rhywogaeth ar ddeg o chwilod a dwy rywogaeth o gorynnod) gan yr awdur ar Dywyn Niwbwrch, er mai'r chwilen ddaear *Harpalus attenuatus* yn unig a gysylltir â chynefinoedd twyni. Ychwanegwyd dwy rywogaeth arall o chwilod gan John Bratton. Y chwilen filwrol RDB3 *Cantharis fusca* – a gofnodwyd ar dwyni a phantiau gwlyb a ddefnyddid fel cymhariaeth sefydlog, a hefyd ar bantiau gwlyb a gloddiwyd – yw'r cofnod cyntaf yng Nghymru er 1906. Mewn pant gwlyb a gloddiwyd, cofnodwyd un chwilen grwydr *Gabrius exiguus* wrywaidd – o fewn y DU, dim ond ar Dywyn Niwbwrch y mae'r rhywogaeth hon i'w chael, cyn belled ag y gwyddom.

Trwy ddefnyddio data a ddeilliodd o arolygon y gorffennol, trafodir newidiadau posibl mewn creaduriaid di-asgwrn-cefn yn ystod y deng mlynedd ar hugain diwethaf. Ymhellach, cofnodir ambell sylw achlysurol yn ymwneud â newidiadau mewn planhigion ac anifeiliaid.

2. Executive Summary

As part of dune rejuvenation on Newborough Warren, the vegetation on the surface of three slacks was scraped down to bare sand and deposited on the dunes bordering the slacks in March 2013. Also the vegetation of the dunes was removed surrounding these areas of the slacks. The areas so treated can be seen in aerial photographs in the report. Invertebrate monitoring, using pitfall traps, focussed on the two excavations furthest inland, with an adjacent slack used as a control. The excavation nearest the sea was not monitored for logistical reasons. The trapping was carried out from the 3rd May – 8th October 2013 and involved a total of 5465 effective trap nights spread across 17 sampling sites. All Coleoptera (beetles), Orthoptera (grasshoppers & allies), Diplopoda (millipedes), Chilopoda (centipedes), Isopoda (woodlice), Araneae (spiders) and Opiliones (harvesters) were identified and counted. A data set of 298 species and 12,838 individual invertebrates was obtained. Whilst the excavations will have resulted in the loss of most resident species, there was evidence for the apparent colonisation of the excavated slacks by five species of beetles characteristic of embryo slack habitat, including the ground beetles *Bembidion pallidipenne* and *Dyschirius politus*, the rove beetles *Bledius subniger* and *Gabrius osseticus*, and the long-toed water beetle *Dryops nitidulus*. Many species, such as *B. pallidipenne*, *B. bruxellense*, *Helophorus alternans* and *Hydroglyphus geminus*, have not been recorded in the dune slacks in previous surveys.

Thirteen species (11 beetles and two spiders) were recorded by the author for the first time on Newborough Warren, although only the ground beetle *Harpalus attenuatus* is associated with dune habitats. A further two beetle species were added by John Bratton. The RDB3 soldier beetle *Cantharis fusca*, which was recorded from control dune and slack areas and excavated slacks, is the first Welsh record since 1906. A single male of the rove beetle *Gabrius exiguus*, which in the UK is only known from Newborough Warren, was recorded in an excavated slack.

Using data from previous surveys, the possible changes in the invertebrate fauna over the last 30 years are discussed. Some casual observations of plant and animal changes are put on record.

3. Introduction

3.1. Background to Dune Invertebrates

Dune invertebrate assemblages are a SSSI Qualifying feature on 15 dune systems in Wales, including Newborough Warren – Ynys Llanddwyn SSSI on Anglesey. The dune assemblage at Newborough currently comprises 208 species of which 29 (Grade 1) are restricted to coastal dunes in the UK, an additional 67 (Grade 2) are restricted in Wales to coastal dunes and 112 (Grade 3) are mostly confined to dunes in Wales. The total includes 87 species of beetles, 42 flies, 33 bees & wasps, 17 bugs, 14 spiders, 11 moths and a single cockroach, lacewing, snail and woodlouse. These exploit a wide range of habitats and conditions, with habitat analysis identifying 11 important elements (Key Habitats):

1. bare mud in mature dune slacks, saltmarsh transition, pool margins, etc.;

2. wet or damp bare and sparsely vegetated sand (pioneer dune slacks etc.);

3. dry bare/sparsely vegetated sand;

4. dry bare or sparsely vegetated firm sand (blow-outs, margins of paths, etc.);

5. phytophagous on low plants in open sand;

6. beach flora (*Cakile*, *Beta*, *Agropyron*, etc.);

7. tussocks/litter in yellow dunes (marram and lyme grass);

8. dry herb-rich grassland (fixed dune);

9. wet or damp vegetated areas (mature dune slacks etc.), inc. creeping willow;

10. dung or carrion on sand;

11. strandline (including accumulations of decaying seaweed) & lower shore.

197 of the 208 species (11 species have no known habitat associations) have been assigned to one of these Key Habitats, with 148 (75%) associated with early successional habitats such as pioneer dune slacks and bare and sparsely-vegetated sand.

Given that SAC dune habitat monitoring should ensure acceptable habitat quality for invertebrates in vegetated areas, habitat quality monitoring for the invertebrate components of the dune assemblage needs to focus on bare and sparsely-vegetated areas of wet sand and mud and dry areas of firm sand. Whilst some progress has been made to develop attributes and thresholds for bare firm sand, and a sampling programme is being established to enable the assessment of condition, more information is needed in order to assess the habitat and faunal condition of pioneer slacks.

Pioneer dune slacks are defined as dune pools (including artificial stock watering pools) & shallow streams (SD110), bare mud in mature dune slacks, saltmarsh transition, pool margins (SD430) and wet or bare and sparsely-vegetated sand (SD435). Slacks dominated by stands of creeping willow (SD545) or tall fen (SD330) are not included. An active dune system on the west coast of Britain should periodically create new blow-outs that give rise to pioneer dune slacks. Over time, as inland slacks become vegetated, there will be a succession of slacks, from young to mature, supporting a range of plants and animals adapted to the different degrees of stability. Fossilisation of systems, however, has led to few new slacks being created and as a result the fauna associated with the temporary pools and damp sandy margins of such habitats is now scarce on many sites. This is evident from the invertebrate data for Newborough Warren, with very few recent records for 20 species (16 beetles and 4 flies) associated with Key Habitat categories 1 & 2 - *Limnophora scrupulosa* (SD110), *Bembidion clarki*, ***Dyschirius salinus***, *Gabrius osseticus*, *Heterocerus flexuosus*, ***Pherbellia grisescens***, *Syntormon filiger* and *Thinobius brevipennis* (SD430), and ***Asaphidion pallipes***, ***Bembidion pallidipenne***, *Bledius fergussoni*, *Bledius fuscipes*, *Bledius longulus*, *Bledius opacus*, *Bledius subniger,* ***Dryops nitidulus***, ***Dryops striatellus***, *Dyschirius politus, Dyschirius thoracicus* and ***Nephrotoma quadristriata (SD435). Seven species*** (emboldened above) have been identified as Key Species – of higher conservation status that generally inhabit specialised micro habitats and are indicative that high quality habitats are being maintained – and four of these have apparently not been seen for over twenty years. This may be due to a lack of survey effort in these habitats, but given the stabilisation of the dunes that has occurred over this period it is also possible that they may no longer be present. Mature slacks currently lack any habitat to support this faunistic element and drinking ponds excavated for grazing stock are too heavily trampled by ponies. This churning of the substrate destroys the burrows of wet sand invertebrates just as it does in dry sand habitats and hence it is unlikely that a rich fauna currently thrives in these situations.

3.2. Dune Rejuvenation and Invertebrates

Excavations were carried out in three slacks on Newborough Warren NNR in March 2013 (Appendix B, Photos 1 & 2; see Howe *et al*. 2014). The aim of this work was to reproduce pioneer slack habitat that has been almost lost on the dune system (Bratton 2012). It is hoped that this intervention will favour the rejuvenation of populations of plants, and particularly bryophytes such as petalwort *Petalophyllum ralfsii*, and invertebrates that depend on these pioneer conditions. As well as specialist species, there are a number of invertebrate species that, though not confined to dune slacks, were once common in the slacks and have either apparently disappeared or become scarce (Loxton 2009).

Two slacks were chosen for monitoring, which lay inland of the third slack (see Figure 1), and in both areas the surface vegetation was scraped off and deposited on the adjacent dune ridges. As well as clearing vegetation from the surface of the slacks the surface of the dunes at the windward (NE) end of the slacks was also scraped off. This can be seen in the Photos 1, 2, and 3 in Appendix B. Photo 4 is an aerial view of the study site and shows the extent of vegetation clearance and the position of the slacks in relation to the shoreline (bottom left). The third excavated slack, unmonitored here, can be seen in the middle and towards the bottom of the photograph. The recent work at Newborough Warren NNR with pitfall traps in 2007

and 2008 in three slacks at SH 41277 63205, SH 41548 63409 and SH 42087 63889 (Loxton 2009) can be used as supplementary information concerning the recent invertebrate community in these habitats. As was discussed in Loxton (2009), earlier observations in 1963/4 and 1980-82 in a more inland slack at SH 429635 indicated that by 2007/8 there had been an apparent retreat of some invertebrate species from the more inland dune and slack areas to the more open dunes behind the beach. Several species that had been abundant in the slacks had become scarce and others were not found. These changes have been assumed to be the result of the increasing plant cover on the dunes and in the slacks, perhaps as consequence of reduced water levels caused by the adjacent forestry plantation (although this is disputed).

The decision not to monitor the more seaward intervention was based on consideration of the time and effort involved in carrying fluid and equipment further still to a rather small slack. Nevertheless this third slack is nearer the beach and may be more likely to be re-colonized by dune fauna from the open dunes behind the tide line. It may be possible to monitor it in 2014. Another slack next to the excavated slacks was monitored in the same way to act as a control (see Appendix B, Photo 4 - where it lies to the west and slightly southwards of the two inland excavated slacks).

There are difficulties in interpreting the results of pitfall trapping which must be considered and will be briefly discussed later. Nevertheless for all its imperfections the technique allows for the capture of a wide variety of species – some in large numbers. It provides a means of obtaining an overall appreciation of some of the ground fauna though without obtaining data of a strictly quantitative form such as the number of individuals/m^2. As will become apparent when the results are presented, it is also difficult to assess whether a species' detection is merely adventitious or whether it represents residency. It would be hoped that monitoring will continue to determine whether true colonization has taken place. Even these preliminary results will be seen to indicate that this expectation is likely to be realized. Perhaps this should come as no surprise as many of these animals are highly mobile and some have probably evolved to colonize transient habitats.

3.3 Objectives

The aim of the current study is to monitor by pitfall trapping the effects upon selected dune invertebrates of the excavation of the surface vegetation of two slacks and the dunes bordering their NE ends. A few observations of a general nature pertaining to the vegetation of the dunes are given in a short section after the results.

4. Methods

The pitfall traps were light-weight 0.5 litre plastic beakers. These fit closely into one another, and the outer one was placed permanently in the sand whilst the inner beaker could be taken out, the catch removed, and then replaced with a clean beaker. The outer beaker was drilled in the base and the inner beaker drilled about 6 cm from the bottom. This allowed excess rain water to drain from the inner beaker, holding the catch, and leaving through the outer. The catch was retained in the trap by a saturated solution of salt (sodium chloride), approximately 6cm deep. This brand

of beaker has a ridge 4cm from the mouth on which a filter can rest. This filter consisted of thin, black plastic pierced by closely packed 1.5cm diameter holes and is effective at excluding small mammals, lizards, and amphibians. It allows entry to the largest beetles likely to be caught such as *Carabus* species and animals with wide leg-spans such as harvestmen. The only vertebrate that has been killed in this study was a single, small newt. Over the top of the trap some fine-mesh wire netting was pegged down. This discourages the attentions of foxes and corvids (Appendix B, Photos 5 & 8). Material collected in the field was pooled for each site, washed through a fine filter and then stored in saturated salt solution until it could be identified. Much of the material is familiar to the author and could be securely identified, if somewhat laboriously. With a reference collection from previous surveys that consists of specimens checked by specialists and compared to the collections at Liverpool Museum, the identifications can be taken as reliable. In a few cases where there is uncertainty, I have indicated this in the data tables – however this only concerns a few species represented by only a few captures.

Initially, three traps were placed in a row about 4m apart at each of 17 sites. The positions of these sites are shown on the aerial photo in Figure 1. This system worked well in the control slack but there were difficulties at all the sites in the excavated slacks. The greatest problem was when the surface of the sand dried out and there was strong wind. As a result of the excavations, the surface sand in both slack and dune blew into the traps and flooded them. The main problem was on the excavated dunes and here, in order to get any samples, six traps were used some of the time and though it had been planned to collect the samples every 4-5 days it was found necessary to visit every two days in windy conditions and reset the traps. Another problem came from the ponies that seemed to delight in galloping over the excavated slacks and often damaged traps. There was considerable sand churning by the ponies on the dunes and also on the slacks (Appendix B, Photo 3). In addition, at least one of the ponies could be observed deliberately pawing and crushing traps with a front hoof – perhaps it was stimulated by the sound of scrunched plastic. Records were kept of how long traps were out of action and the number of effective trap nights calculated at each site. The mean number of effective trap nights at the 17 sites was 321.5 (with a range of 261 to 410). The data for each species and site was corrected for trapping effort (divided by number of effective trap nights at each site) and then expressed as corrected numbers of individuals caught in 300 trap nights. The choice of 300 trap nights was based on a round number that would express the catch of a single animal as approximately 1.This figure for each site is used to calculate the mean number of animals caught in each of four treatments. The raw data is cumbersome - 18 columns and some four hundred rows - and has not been presented in this report but is available if required. These habitats were 3 sites of Control Dunes (CD), 3 sites of Control Slacks (CS), 6 sites of Excavated Dunes (ED) and 5 sites of Excavated Slacks (ES). The calculated means can be used as a basis for examining the effects of the intervention and can be inspected in the tables provided. The original naming of the slacks when the project was started was Slack 1 (Control Slack, C), Slack 2 (Excavated Slack 1, E1) and Slack 3 (Excavated Slack 2, E2). I have preferred the designations Control and Excavated as having more descriptive relevance.

Figure 1: Position of the trapping sites. The red stars indicate the position of the middle trap in a row of three.

The sites were positioned on the dunes flanking the slacks CD1, E1D1 and E2D1 on the western flank, CD2 etc on the parabolic face of the dune and CD3 etc on the eastern flank. In the slacks, CS1 etc were the sites nearest the parabolic face and probably the wettest sites. CS2 etc and CS3 etc were progressively more seaward sites in the slacks. The location of the trapping sites was chosen on the ground in some cases to avoid the most obvious routes taken by the ponies. Some of the trapping sites are shown in Appendix B, Photos 6-9. Trapping started 3rd May 2013 and was temporarily halted on 22nd July. Trapping re-started on 26th August and was finished on 9th October. The trapping involved some 42 visits to the site.

The beetles, spiders, harvesters, grasshoppers, woodlice, millipedes and centipedes were identified and counted. There were a few small aleocharine staphylinids that are yet to be identified but have been ignored for the present report. I had intended to include all the true bugs and the Auchenorrhyncha but there were few true bugs and these were of limited interest being mostly found in the control slack. The Auchenorrhyncha were more numerous but also mainly in the control slack. I have counted the numbers of a single species of bug, *Salda saltatoria.* All the un-identified material has been preserved and will in due time be looked at and perhaps incorporated in the results of future monitoring.

5. Results

The numbers of species and individuals for the data set are shown in Table 1.

Table 1. Number of species and individuals by invertebrate order.

	Number of species	Number of individuals
Beetles	**184**	**5437**
Ground beetles	46	
Rove beetles	56	
other beetles	82	
Spiders	**81**	**3581**
Harvesters	**7**	**463**
Woodlice	**3**	**2729**
Millipedes	**6**	**546**
Centipedes	**1**	**12**
Grasshoppers & allies	**5**	**70**
Earwigs	**1**	
True bugs	**1**	
Bees, wasps & ants	**9**	
Total	**298**	**12,838**

It was surprising that only one species of centipede was recorded as several species have been previously found (Loxton, 2009). A striking feature of the data was how many species were represented by only a single capture - 45 species of beetles (24.3%), 21 species of spiders (25.6%) and one species of harvester. Although there is a tendency to feel that the fauna of Newborough Warren, at least in some taxa, is well known, 11 species of beetles and two species of spiders were recorded for the first time from the reserve. These are:

Beetles

Bembidion bruxellense	Local
Harpalus attenuatus	Local
**Carpelimus pusillus*	Local
Lomechusa emarginata	Nationally Scarce
Othius angustus	Common
Gabrius appendiculatus	Common
Cantharis fusca	RDB3
Oedostethus quadripustulatus	Nationally Scarce
Anobium punctatum	Common
Longitarsus succineus	Common
Oxystoma cerdo	Nationally Scarce

Spiders

Milleriana inerrans	Local
Pirata uliginosus	Local

* found by hand searching in one of the excavated slacks

Only one, *Harpalus attenuatus,* is associated, though not exclusively, with sand dunes and is regarded as a Grade 3 species (Mike Howe, pers. comm.). It has been recorded from the neighbouring Tywyn Aberffraw. Several specimens of *Cantharis fusca* were recorded (from control dune and slack areas and excavated slacks – see Table 5), the first time this species has been found in Wales since 1906.

5.1. Records from John Bratton

John Bratton visited the site on 8th June 2013 and provided the following records from the water and damp sand of the excavated slack at SH4207 6343, including two further new records (marked with *) for Newborough Warren.

Table 2: Beetle records from the Newborough Warren excavated slack, John Bratton June 2013. Note that *Hydroglyphus geminus* was formerly *Guignotus pusillus* (Fab.) – it is a typical pioneer species and has also been recorded in new scrapes on Maltraeth Marsh RSPB reserve.

Species	Status	Comment
Helophoridae		
Helophorus brevipalpis Bedel	Local	6 adults
H. aequalis Thomsen C.G.	Common	1♂ dissected, 1♀
**H. alternans* Gené	Nationally Scarce	1♂ dissected
Dytiscidae		
Agabus bipustulatus (L.)	Common	teneral ♂
**Hydroglyphus geminus* (Fab.)	Nationally Scarce	1 adult
Hydroporus planus (Fab.)	Common	4 adults
H. pubescens (Gyllenhal)	Common	1 adult

5.2. Species Data

Another feature of the data was that far fewer individuals of many of the abundant species were caught in the excavated sites – hardly surprising after such a radical disturbance of the vegetation. The data can be compared between treatments by using the corrected numbers of beetles caught at each site and then calculating the mean number of beetles for each species in each treatment. This manipulation allows trapping effort and differing numbers of sites in the four treatments to be taken into account. For the carabid beetles, there was a ratio of 8.3 **:** 1 (CD**:**ED) and 11.8 **:** 1 (CS**:**ES). For all beetles, the ratios were somewhat lower – 5.9 **:** 1 (CD**:**ED) and 6.8 **:** 1 (CS**:**ES). For spiders, the ratios were higher, with only small numbers caught on the Excavated Dunes – 23.4 **:** 1 (CD**:**ED) and 14 **:** 1 (CS**:**ES). Some of the details of the data leading to these ratios will be pointed out in considering the tables below. Bratton (2012) listed 16 species of beetle as 'Target' species for the pioneer dune slack habitat. Only five of these (*Bembidion pallidipenne*, *Bledius subniger*, *Dryops nitidulus*, *Dyschirius politus* and *Gabrius osseticus* – see Introduction) were caught in this survey and have their names emboldened in red in the tables below.

Table 3: Mean number of carabid beetles/treatment calculated from numbers corrected for trapping effort. Pioneer dune slack species are highlighted in red.

	Mean beetles/site Control Dunes	Mean beetles/site Control Slacks	Mean beetles/site Experimental Dunes	Mean beetles/site Experimental Slacks
Carabus violaceus	0.3	0.3		
Cychrus caraboides	3.8	0.7		0.2
Dyschirius globosus	0.3	6.3		0.6
D. impunctipennis				**0.2**
D. politus				**0.6**
Leistus terminatus	3.5	0.3	0.2	0.2
Nebria brevicollis	0.3	2.8	0.3	0.4
N. salina	8.5	80.4	2.9	9.9
Notiophilus aquaticus		7.3		0.5
N. substriatus		1.0		0.4
Elaphrus riparius				**11.9**
Bembidion bruxellense				**0.2**
B. pallidipenne				**1.4**
B. quadrimaculatum				0.4
Pterostichus niger	5.9	5.6	0.6	1.3
P. strennuus	3.4	2.1	0.1	0.4
P. vernalis	0.7	17.0		
P. versicolor	0.3	129.5	0.2	0.8
Calathus cinctus	0.7		0.3	0.2
C. erratus	13.2	0.3	5.1	0.4
C. fuscipes	91.1	213.5	3.5	5.1
C. melanocephalus	8.3	8.3	1.8	1.4
C. mollis	0.4		0.6	
Amara aenea	5.7	1.7	0.3	1.0
A. communis	4.5	19.1	0.2	0.2
A. convexior	4.5	7.0	0.1	0.6
A. familiaris	0.3			
A. lucida	2.1		0.5	
A. lunicollis	6.1	0.3	0.0	
A. praetermissa	2.5	3.1	0.3	
A. similata	8.2	2.4	0.4	0.2
A. tibialis	1.8	2.8	0.1	0.4
Agonum marginatum				**0.4**
Harpalus anxius	2.8		1.5	0.6
H. attenuatus			**0.4**	
H. latus			0.1	0.2
H. neglectus	0.7		0.8	
H. rufipes	0.3			
H. tardus	1.4	0.3	0.3	0.4
Anisodactylus binotatus		0.3	0.1	0.2
Badister harpalinus	0.4	0.7		
Acupalpus dubius		2.8		

Trechus obtusus	3.1		2.0	0.6
Badister bullatus	7.9	3.5	2.5	1.5
Paradromius linearis			0.1	
Syntomus foveatus	18.7	1.0	0.1	1.2

Some of the numerical data in Table 3 above that may be of particular interest has been shown in bold. *Dyschirius impunctipennis* (represented by only a single capture) was last seen on the dunes by the author in the early 1960s. Luff (2007) gives the habitat as 'on fine sand in salt marshes', and for *D. politus* 'on bare sand or silt, not always near water, also in salt marshes'. *Elaphrus riparius* was numerous in both the excavated slacks in late summer, running on the bare sand, and though it was a familiar species in dune slacks in the 1960s (pers. obs.) it has not been commonly seen since except at the edges of horse ponds on the dunes. The large numbers taken in the pitfalls argues for colonisation by this species. It could, of course, be a relict fauna of the small pond that existed in Excavated Slack 2 (ES2) before the intervention but it was much more numerous in Excavated Slack 1 (ES1) which did not previously have a pond. A single specimen of *Bembidion bruxellense* in ES1 ('on moist, usually open ground, also damp grasslands near water' - Luff 2007) is a new record for Newborough Warren. Of greater interest is *Bembidion pallidipenne* which I have never seen in dune slacks before - a total of seven specimens were taken, spread between ES1 and ES2. *Agonum marginatum,* as for *Elaphrus riparius,* was once a common species in the slacks and their recent decline is perhaps a result of the increasing plant cover in the slacks, or increasing dryness. Finally, *Harpalus attenuatus* has not been recorded on Newborough Warren before – surely it has been overlooked – but three were taken on the excavated dunes.

Table 4: Mean number of staphylinid beetles/treatment calculated from numbers corrected for trapping effort. Pioneer dune slack species are highlighted in red.

	Mean beetles/site Control Dunes	Mean beetles/site Control Slacks	Mean beetles/site Excavated Dunes	Mean beetles/site Excavated Slacks
Bolitobius castaneus	1.7			
Mycetoporus splendidus	2.4	3.5	1.5	0.7
M. piceolus	2.5	0.3	0.4	
Sepedophilus nigripennis	1.0	0.3	0.3	0.7
Tachyporus atriceps		1.0		
T. chrysomelinus		1.7		0.2
T. dispar	1.1			
T. nitidulus	0.7		0.1	
T. pusillus		2.4		
T. solutus	0.7			
T. tersus		0.7	0.1	0.6
Pella limbata	11.8	0.7	0.1	1.2
Lomechusa emarginata	0.3			
Drusilla canaliculata	9.0	3.1	5.3	3.9
Arena tabida			**0.1**	
Atheta brunneipennis		1.0		

Aleochara ?grisea			0.2	
Aleochara punctatella			0.1	
Anotylus rugosus		0.2	1.6	0.1
Anotylus tetracarinatus			0.4	
Bledius gallicus		**0.3**		**0.2**
B. longulus				**0.1**
B. opacus			**2.1**	**0.6**
B. subniger				**6.9**
Stenus clavicornis	4.9		2.1	0.2
S. impressus	0.1			
S. nanus		1.0		
Lathrobium brunnipes			0.1	
L. geminum		0.1	0.1	
Octhephilum fracticorne	1.4	2.8	2.3	0.7
Rugilus erichsoni		0.3		
Othius angustus			0.5	
O. laeviusculus	0.4		0.3	0.2
O. punctulatus	0.3			
O. subuliformis	0.1	0.1	0.2	
Gabrius appendiculatus		0.3		
G. breviventer		0.3		
G. exiguus				**0.2**
G. osseticus		**0.7**	**3.3**	**3.7**
Philonthus cognatus				0.2
P. marginatus		0.3		
P. quisquiliaris				0.2
Quedius boops		1.0		
Q. levicollis	7.7	6.6	0.6	0.5
Q. molochinus	0.3		0.3	
Q. persimilis	1.1			
Q. picipes	0.7	1.0	0.3	0.2
Q. semiobscurus	5.7	3.1	1.3	1.8
Ocypus olens	8.3	0.3	0.2	0.2
O. aenocephalus	4.9	16.7	0.3	0.2
O. brunnipes	1.4	7.3	2.9	1.2
Platydracus stercorarius	1.0	3.8		
Staphylinus dimidiaticornis	0.3	6.2		
Tasgius globulifer	1.8	0.3		
Xantholinus linearis	5.9		3.7	0.8
X. longiventris	5.2	4.5	5.1	1.4

Among the staphylinids in Table 4, the capture of a single specimen of the small *Arena tabida* on the excavated dunes is worth noting. This species is found, in my experience, on the yellow dunes immediately behind the tide line where it can be abundant in pitfalls. One might presume that it was displaced inland by wind. That it turned up on an extensive expanse of bare sand may just be adventitious but it is tempting to speculate that a rise of bare sand from the level slack might appear as the beach and tide line to a dispersing insect. Several species of *Bledius* were found principally on the Excavated Dunes and Slacks - these are all associated with sandy

places and *B. subniger,* which was caught in greater numbers than the other species, is known from 'damp sandy places by the coast, saltmarsh' (Lott 2009). A single male of *Gabrius exiguus* was taken in ES1 - this very rare beetle is only known from Newborough Warren in the British Isles. *Gabrius osseticus* is also of interest as it is one of the Target Pioneer Slack species and a total of 47 specimens were taken, all but two on the excavated slacks and dunes.

Table 5 displays the captures of the remainder of the beetles. The two water beetles *Colymbetes fuscus* and *Hydroporus planus* were taken in the summer when there was no open water in the excavated slacks – these must be dispersing insects and their presence is merely adventitious. Similarly the Furniture Beetle, *Anobium punctatum,* must be in a similar situation though there is some rotten wood on the warren and along the tide line, and of course the forest is not far away. *Cercyon littoralis* is found under rotting seaweed on the tide line and is presumably in a similar situation to *Arena tabida* discussed above. *Hypocaccus rugiceps,* although Nationally Scarce*,* is a common species of yellow dune on Newborough Warren and in the past (see Table 8 below) was common in the early 1980s on the landward dunes – perhaps this single capture is a case of incipient re-colonisation of the bare sand habitat. *Hyperaspis pseudopustulata* is a small ladybird of woodland (Majerus & Kearns 1989), and again its presence must be accidental – I have found it previously within Newborough Forest.

Table 5: Mean number of beetles/treatment (other than carabids and staphylinids) calculated from numbers/site corrected for trapping effort. Pioneer dune slack species are highlighted in red.

	Mean beetles/site Control Dunes	Mean beetles/site Control Slacks	Mean beetles/site Excavation Dunes	Mean beetles/site Excavation Slacks
Dytiscidae				
Colymbetes fuscus				**0.4**
Hydroporus planus			**0.1**	
Helophoridae				
Helophorus aequalis				**0.9**
H. brevipalpis		**0.3**	**1.3**	**8.7**
Georissidae				
Georissus crenulatus		3.5		
Hydrophilidae				
Anacaena limbata			0.1	
Cercyon littoralis				**0.2**
Megasternum concinnum	5.2	0.7		0.4
Histeridae				
Hypocaccus rugiceps			**0.1**	
Leiodidae				
Leiodes rufipennis	0.7	2.8	0.3	0.2
Agathidium convexum	0.7			
A. laevigatum	1.1	0.7	0.2	0.2
Catops fuliginosus	0.7	0.3	0.3	

Catops sp ♀			0.1	
Silphidae				
Silpha atrata	2.1	1.7	1.2	0.2
Sipha tristis		0.3		
Scarabaeidae				
Hoplia philanthus	18.2	2.4	6.0	3.2
Sericea brunnea	5.5	5.6	18.9	4.9
Phylopertha horticola				0.9
Onthophagus similis	0.3	7.0	0.4	1.0
Aphodius depressus	0.3			
A. contaminatus		0.7	0.3	0.2
A. erraticus			0.1	
A. foetens			0.1	
A. plagiatus		**0.3**		
Byrrhidae				
Cytilus sericeus	0.4	49.3		0.2
Dryopidae				
Dryops ernesti		**50.4**	0.2	3.3
D. luridus		**3.8**	0.1	
D. nitidulus	**1.1**			**1.6**
Elateridae				
Agrypnus murinus	19.6	3.1	2.6	2.9
Cardiophorus asellus	1.1	0.3	0.3	0.2
Agriotes obscurus	0.4			
A. lineatus		40.3		
Agriotes pallidulus	1.7	0.3	0.6	0.2
Oedostethus quadripustulatus			0.1	
Lampyridae				
Lampyris noctiluca	1.0	0.5		0.1
Cantharidae				
Cantharis fusca	0.3	0.7		0.2
C. nigricans	0.7	0.7	1.7	0.4
Anobiidae				
Anobium punctatum			**0.1**	
Nitidulidae				
Meligethes exilis	1.1		0.4	
Phalacridae				
Olibrus affinis			0.2	
Coccinellidae				
Rhyzobius litura	0.7		0.1	
Scymnus frontalis				0.2
S. schmidti	1.1			
Hyperaspis pseudopustulata			**0.1**	
Coccinella septempunctata	0.4		0.1	
C. undecimpunctata			0.4	
Latridiidae				
Corticaria crenulata	0.3		0.1	
Tenebrionidae				
Phylan gibbus	**15.8**	**0.3**	**3.5**	**0.2**

Melanimon tibialis	**0.3**		**1.0**	**0.2**
Isomira murina	2.4		0.4	1.2
Cteniopus sulphureus	0.4		1.0	
Chrysomelidae				
Cryptocephalus fulvus	0.3			
Galeruca tanaceti	5.5	0.7		0.2
Longitarsus jacobaeae	1.1	1.7		
L. luridus	0.3			
L. succineus ♂	0.3			
Neocrepidodera ferruginea	16.0	1.4	0.7	0.6
N. transversa	1.4	1.0		
Sermylassa halensis	0.7			
Apionidae				
Squamapion atomarium	1.0		0.3	
Holotrichapion ononis	0.4			
Oxytoma ?cerdo			0.1	
Ischnopterapion loti	0.7	1.0	2.0	
Protapion fulvipes				0.2
P. ononidis	0.4		0.1	
Erirhinidae				
Grypus equiseti			**0.1**	
Curculionidae				
Orthochaetes insignis	0.3		0.2	
O. setiger				0.2
Glocianus punctiger	0.3		0.1	
Trichosirocalus troglodytes	0.7			0.2
Pelonomus quadrituberculatus				0.2
Rhinoncus pericarpius	0.3			
Philopedon plagiatus	**10.4**	**1.4**	**61.6**	**6.7**
Otiorhynchus ovatus	4.9	1.0	2.0	0.4
Charagmus griseus	3.9	0.3	3.4	1.1
Sitona ambiguus	0.4		0.2	
S. lineatus			0.7	
S. lineellus	1.4		1.5	0.2
Orobitis cyanea	2.4	0.3	0.1	0.2
Hypera nigrirostris	3.5		1.0	0.4
H. plantaginis		3.5	1.4	0.4
H. zoilus		0.3	0.3	

A single specimen of *Grypus equiseti* on the excavated dune must also be a dispersing individual – as its name suggests, it feeds on *Equisetum* and is occasionally found in wet slacks. On the other hand, only a single specimen of *Aphodius plagiatus* in the Control Slack is a sign of the change that has occurred over the last 50 years. In the early 1960s, this amount of pitfall trapping in the Control Slack might have yielded hundreds of specimens of *A. plagiatus* – this is one of the species likely to colonise the excavated slacks as they begin to mature. The *Dryops* species were not common in the excavated slacks and, like *A. plagiatus,* should flourish with the early vegetation of the excavated slacks. On the other hand, the highly mobile and common *Helophorus* species were abundant in the excavated

slacks, particularly early in the season when the sand in the excavated slacks was damp or there was some open water.

The two common species of sand dunes, *Phylan gibbus* and *Melanimon tibialis,* were present on the dunes of the control and excavated slacks though *M. tibialis* was not abundant. On the dunes of the Cefni Estuary, I have walked transects at right angles to the shore and *M. tibialis* occupies a distinct zone inside the yellow dune where small forbs begin to colonise the sand surface and the grasses are not dense. In this zone, it can be seen in large numbers on the surface of the sand in bright sunshine in the spring. Further inland where there is dense marram, the species becomes uncommon or absent. Although the exact habitat of this species has not been described, it seems likely that its preferred habitat has been reduced on the inland dunes. I have found that *P. gibbus* on the Cefni Estuary dunes lives among taller vegetation, probably reflected in the greater numbers taken here.

Philopedon plagiatus in this survey is unique in being apparently encouraged by the excavations. It was taken in large numbers on the excavated dunes and numerously in the excavated slacks. This species is a familiar sight in the spring clumsily attempting to climb out of blowouts in the yellow dunes. However it is nocturnal, and sweeping marram or searching with a lamp at night reveals an abundance of this weevil. It is a spring breeder with larvae feeding on the roots of dune grasses through the summer and pupation occurs probably in late summer and it probably over-winters as an adult, emerging in early spring. It is suspected that the beetles were mostly below the level of the excavations and emerged onto the bare sand to blunder into pitfalls.

The spiders and harvesters taken in this survey are shown in Table 6 above. The dune specialist *Ceratinopsis romana* was not taken but in my experience, though found on previous surveys of Newborough Warren, it has never been numerous in pitfalls. *Mecopisthes peusi* a species that, on the west coast of Britain, is confined to coastal sand dunes. It can sometimes be abundant on Newborough Warren (Loxton 2009) but disappointing numbers were found on the Control dunes. Both these spider species may benefit from refreshed dune habitat. The one species that appears to have benefited from the intervention was the wolf spider, *Arctosa perita* that was taken in large numbers in the excavated slacks – however, I suspect that this is at least partly an artefact of the altered environment allowing greater mobility on the excavated slacks.

Table 6: Mean number of spiders and harvesters/site calculated from numbers corrected for trapping effort.

	Mean arachnids/site Control Dunes	Mean arachnids/site Control Slacks	Mean arachnids/site Excavation Dunes	Mean arachnids/site Excavation Slacks
Mimetidae				
Ero furcata	0.3			
Theridiidae				
Neottiura bimaculata	0.3	0.35		
Enoplognatha thoracica	2.4	8.69		0.38
Robertus lividus	0.4			
Linyphiidae				
Ceratinella brevipes	0.7	0.35		0.18
Walckenaeria antica	1	0.35		0.18
W. atrotibialis	4.5	0.35		
W. monoceros	0.4	0.70		
W. nudipalpis	0.3	0.00		
W. vigilax	0.7	1.39		0.23
Dicymbium nigrum		0.35		0.18
Maso sundervalli	0.3			
Peponocranium ludicrum	0.7			
Pocadicnemis pumila	4.1			
Troxochrus scabriculus		3.14		0.20
Oedothorax fuscus		3.82	0.47	1.33
O. gibbosus				0.21
O. retusus		0.35	0.16	
Minyriolus pusillus	0.34		0.31	
Silometopus ambiguus		0.35		
Mecopisthes peusi	**2.84**	**1.04**		**0.61**
Tiso vagans		0.35		
Monocephalus fuscipes		0.35		
Araeoncus humilis			0.15	
Cnephalocotes obscurus	5.87	1.73		0.18
Tapinocyba praecox	0.35			
Gongyllidielum vivum	1.40	0.69		0.18
Erigonella hiemalis	1.72			
Milleriana inerrans	0.00			1.83
Erigone atra	0.71	32.38	0.42	5.63
E. dentipalpis	0.35	30.26		7.64
E. longipalpis				0.84
Argyneta decora		0.70		
A. ?conigera ♀			0.16	
Centromerus prudens	0.34			
Centromerita concinna	0.34	7.64		0.18
Bathyphantes gracilis		0.35	0.13	0.39
B. parvulus				0.18
Tapinoma longidens				0.06
Bolyphantes luteolus			0.16	

Lepthyphantes ericaeus	1.72			
L. pallidus				0.23
L. tenuis	1.38		0.84	0.18
L. zimmermanni	0.34	0.35	0.52	0.23
Microlinyphia pusilla	0.34			
Tetragnathidae				
Pachygnatha degeeri		26.39		0.43
Lycosidae				
Pardosa monticola	40.82	440	0.92	9.27
P. palustris		10.76		
P. pullata	11.39	47.55	0.80	0.41
P. nigriceps	1.38	4.17	0.28	0.20
P. proxima		0.69		1.68
Xerolycosa miniata	86.26	0.70	1.29	0.23
Alopecosa pulverentata	6.12	16.08	0.14	0.51
A. barbipes		0.69	0.13	0.20
Trochosa ruricola		18.42	0.13	0.99
T. terricola	36.84	15.99	1.03	1.41
Arctosa perita	**9.09**	**2.43**	**1.75**	**11.82**
A. leopardus		14.95		0.99
Pirata uliginosus		1.04		
P. latitans				0.18
Agelinidae				
Tegenaria sp.			0.04	
Agelena labyrinthica	0.34			
Dictynidae				
Argenna subnigra	18.51	15.98	0.92	0.76
Liocranidae				
Agroeca proxima	3.10	0.35		
Scotina gracilipes	2.10		0.16	
Clubionidae				
Clubiona neglecta	0.70	0.35		
Cheiracanthium virescens	1.73	0.35		
Gnaphosidae				
Drassodes cupreus	7.97	2.79	0.26	
D. pubescens	0.69	0.70	0.13	
Haplodrassus signifer	7.63	3.13	0.28	0.18
H. dalmatensis	0.35		0.13	
Z. electus	17.13	0.35		0.23
Zelotes latreillei	8.94	5.56		0.23
Micraria pulicaria	1.38			
Thomisidae				
Xysticus cristata	3.49	10.07	0.13	0.35
X. kochi	3.83	2.44	0.31	1.28
X. erraticus	1.03	4.51		0.20
Ozyptila trux	4.10	1.06	1.03	
O. simplex		17.74	0.13	0.35
O. atomaria	1.37			0.18
Salticidae				

Heliophanus flavipes				0.21
Euophrys frontalis	0.71			0.84
Harvesters				
Nemastomum bimaculatum	0.34	0.35		
Paroligolophus agrestis	2.07			
Lacinius ephippiatus	1.03			
Phalangium opilio	29.77	65.75	8.24	1.41
Opilio saxatilis	18.93	1.74	4.19	0.23
Platybunus triangularis	4.12	0.70		0.41
Leiobunum rotundatum	0.34			

Table 7 gives the data for some miscellaneous invertebrates. Some of the millipedes, for instance *Tachypodiulus niger* and *Ommatioiulus sabulosus,* were surprisingly common on the excavated dunes and slacks. It might be thought that these were harsh environments for such animals but they are often taken away from vegetation. I suspect they get caught in pitfalls when traversing bare sand – indeed, the dark and moist entrance to a pitfall may indeed be attractive. Similarly the woodlice, apart from *Philoscia muscorum,* were found not uncommonly on the excavated areas. The four species of Orthoptera show a different pattern with all but the cockroach *Ectobius panzeri* uncaught in the excavated areas. The bug *Saldula saltatoria* is a common insect in the slacks on Newborough Warren and was numerous in this survey in the control slack. It was also caught in the excavated slacks but only in the wettest sites.

Table 7: Mean number of miscellaneous invertebrates/site calculated from numbers corrected for trapping effort.

	Mean inverts/site Control Dunes	Mean inverts/site Control Slacks	Mean inverts/site Excavated Dunes	Mean inverts/site Excavated Slacks
Millipedes				
Tachypodiulus niger	14.2	1.4	14.2	4.1
Ommatioiulus sabulosus	29.0	8.7	10.8	8.2
Cylindroilus latestriatus	7.3	67.1	3.5	2.7
Ophyiulus pilosus	8.7	1.7	0.1	0.5
Iulus scandinavius	20.7	1.0	0.8	0.4
Polydesmus angustus	1.7	6.6	0.1	
Centipedes				
Lithobius borealis	2.8	1.4	2.9	1.0
Woodlice				
Porcellio scaber	216.3	10.1	10.2	2.7
Armadillidium vulgare	422.4	146.5	8.7	1.7
Philoscia muscorum	132.6	20.1	0.1	0.2
Earwigs				
Forficula auricularia	1.1	3.8	0.1	0.8
Grasshoppers & allies				
Tetrix undulata		8.3		
Ommocestus viridulus	1.7	0.7		
Myrmeliotettrix maculatus	4.6	2.1		
Ectobius panzeri		2.1	0.7	0.2

Heteroptera				
Saldula saltatoria	0.7	56.4		10.8

In an attempt to examine changes in the fauna over the years I have extracted numbers of some species from previous surveys by pitfalls. To make the surveys comparable all the data has been expressed in the form of numbers/300 trap nights. However, the surveys are not strictly comparable as they were made in different slacks and trapping was over different time spans. The 1980s survey was over 25 consecutive months so it included the winter months. The 2007-8 survey ran from June – November 2007 and then from April – June 2008, all months inclusive. Also smaller pitfalls were used in the previous surveys. As it is hoped that this intervention will reverse some of these changes, it is perhaps appropriate to document changes these pitfall trapping surveys appear to show.

As indicated above, caution must be shown in coming to any definite conclusions except perhaps where the figures are strikingly different. The slack and dunes sampled in 1980-83 were inland of the slacks sampled in the present survey. In the 2007-08 survey, the data comes from three slacks nearer the forest edge. It is unlikely that all the slacks are identical in the characteristics that influence the abundance of the different species. It is also worth remembering that populations of invertebrates can vary widely from year to year. I have had the experience of sampling a site (Bardsey Island) where on the same small patch of habitat a species was apparently absent one year but common the next year. Interestingly (perhaps!) this was *Harpalus attenuatus,* a species that has not been recorded before at Newborough - in 2013 three specimens were taken on the excavated dunes. However, in spite of these sources of variation in the data, I think it is possible to see some striking and probably significant differences over the years.

Table 8: A comparison of the abundance of selected beetle species in three surveys. All numbers are expressed as numbers of beetles/300 trap nights. In the first two columns, the letter D after a number indicates beetles found on the dunes, and S the number taken in slacks. Species found principally on the dunes are in red type, those in green at the edge of slacks, with the remainder taken principally in the slacks.

	1980-83	2007-08	2013 Control Dunes	2013 Control Slack	2013 Excavated Dunes	2013 Excavated Slacks
Loricera pilicornis	54S	0.4S				
Elaphrus cupreus	1.5S	1S				
E. riparius	1.5S					**60**
Dyschirius globosus	26D309S	15D 169S	**1**	**19**	**0**	**3**
D. impunctipennis						**1**
D. politus	3D 4S	0.4S				**3**
D. thoracicus	10D 0.5S					
Broscus cephalotes	47D					
Bembidion assimile	**0.1D 15S**	**0.4S**				
B. pallidipenne						**7**
Pterostichus niger	1D 4S	2S	**18**	**17**	**4**	**6**
P. nigrita sl.	5D 54S	62S				
P. strennuus	0.2D 0.1S	2S	**10**	**6**	**1**	**2**
P. vernalis	1D 19S	25S	**2**	**51**		
P. versicolor	6D 11S	**41D 668S**	1	**389**	1	4
Agonum fuliginosum	1D 5S					

A. marginatum	0.2D 9S	0.4S				**2**
A. muelleri	1D 53S	45S				
Bledius fuscipes	9D 1S					
B. gallicus	2D 1S	5S		1		1
B. longulus	7D 1S	1S				0.3
B. opacus	10D 1S				12	3
B. subniger						**34**
Gabrius appendiculatus				1		
G. breviventer	1D 4S	0.4S		1		
G. exiguus	0.1S	0.6D				1
G. keysianus	0.7D 7S	0.4S				
G. osseticus		0.3D		2	**20**	**19**
Platydracus stercorarius	5D 13S	2D 1S	3	11		
Staphylinus dimidiaticornis		29S	1	19		
Georissus crenulatus	2D 67S	8		10		
Hypocaccus rugiceps	81D 1S				**1**	
Hydnobius punctatus	10D 1S					
Aegialia arenaria	10D					
Aphodius plagiatus	14S	18S		1		
Dryops ernesti	0.4D 19S	16S		151	1	16
D. luridus	3D 133S	0.2D 26S		11	1	
D. nitidulus	6D 263S	18S		3		8
D. striatellus	0.1D 4S	0.4S				
Phylan gibbus	69D 1S	30D	45	1	**25**	1
Melanimon tibialis	186D 9S	0.8D	1		**6**	1
Xanthomus pallidus	6D					
Anthicus bimaculatus	5D					
Philopedon plagiatus	29D 2S	64D 3S	31	4	**370**	33

I have included two species in Table 8 to show that the variation in the data may be extreme. These species are *Pterostichus nigrita* sl and *Agonum muelleri* that were both abundant in the two earlier surveys and yet were absent in the present work. This is possibly surprising as both are widespread and common species. One possible explanation is that the slack being used here as a control for the intervention, where these species would have been expected, is exceptional in some unknown way. Both species are associated with damp ground and it seems unlikely that this control slack has so dried out as to make it uninhabitable to these species. A visit on 19th January 2014 to this control slack revealed that there were small patches of open water. Unfortunately, we have no way of being certain whether this is a real loss or merely sampling error.

There are other apparent declines which are consistent with changes in the slack habitat for instance: *Loricera pilicornis*, *Elaphrus cupreus* (never abundant), *Dyschirius globosus* (apparently decreasing, a species that favours open ground), *Bembidion assimile, Agonum fuliginosum*, *Agonum marginatum* (abundant in the 1960s), *Georissus crenulatus*, *Aphodius plagiatus* (in the 1960s this species could be seen abundantly on the surface; it has undoubtedly declined), *Dryops ernesti* appears to have increased and *D. luridus* and *D. nitidulus* to have declined. These changes are probably due to a thicker and taller plant cover in the slacks. *Pterostichus niger* was not known (to me) in the 1960s and appears to be increasing in the slacks and on the dunes. *P. niger* is a large species that is often found abundantly in shaded habitats and its increase is fully consistent with increased vegetation. Another species which also appears be increasing, again unknown to me in the 1960s, is *Pterostichus versicolor,* and it is now the dominant species captured

in pitfalls in the slacks. The large colourful staphylinid, *Staphylinus dimidiaticornis,* was not seen in the 1980s but seems to be increasing in the slacks and can be seen regularly when crossing a slack in the summer. *Elaphrus riparius* had only been occasional in the 1960s and 1980s and it has probably been living around the margins of the excavated ponds made to water ponies. It will be interesting to see if the abundance of *E. riparius* in 2013 in the excavated slacks is sustained.

In the 1960s and 1980s, there was still extensive habitat in the slacks that would have been classified as embryo slack habitat. It existed at the foot of eroding, tall dune faces where damp sand with little vegetation occurred as the dune face retreated inland. This is similar to the habitat shown in a photograph in Bratton (2012) at Tywyn Aberffraw. The group of species in green type were found in this habitat, with the small carabids *Dyschirius politus* and *D. thoracicus* burrowing to find their prey, *Bledius* species, living in this habitat. Some of these *Bledius* species are often found well away from the slacks on dry open sand – I suspect that the breeding habitat of these small staphylinids is not sufficiently well known. Examining my data from the 1980s survey suggests that though the *Bledius* species are often given as taken on dunes, this is a consequence of a broad classification into two habitats, dunes and slacks. They were in fact in a transition zone. *Dyschirius impunctipennis* was seen in this habitat in the 1960s but I had not seen it since until in 2013 the single specimen turned up on the excavated slacks. *Bembidion pallidipenne* has never been found by me outside the salt marsh habitat – this is another species that it will be interesting to see if it establishes in the excavated slacks.

Finally, there is a group of species in red type that are species of dunes with mobile, bare sand. *Broscus cephalotes* was abundant in the 1980s survey which was carried out well inland to the present survey. This large, easily trapped species seems to be lost to the inland dunes though it is abundant on the mobile dunes behind the tide line. Similarly *Hypocaccus rugiceps*, *Hydnobius punctatus*, *Aegialia arenaria* and *Xanthomus pallidus* have all apparently retreated to the coastal dunes where they may still be found. *Anthicus bimaculatus* has not been seen by me since the 1980s survey in spite of extensive pitfall trapping and night searching in suitable habitat on the open dunes of Abermenai Point, on the dunes behind the tide line either side of Llanddwyn Island and on the dunes of the Cefni estuary.

5.3 Aculeate Hymenoptera

The only species that were numerous in the pitfalls were ants. I have not counted these as the number caught is highly influenced by how close a trap is to a nest or foraging trail. Ants were a group that survived the removal of the surface vegetation on the dunes. Soon after I started visiting the dunes in April, ants could be seen foraging from nests under the bare sand. Presumably the nests were far enough under ground to survive the excavation. The commonest species was *Lasius niger,* with frequent occurrences of *Formica fusca, Myrmica rubra, M. ruginodis* and *M. sabuleti*. There was also a single nest of one of the yellow *Lasius* species. Another species that survived was the bee *Colletes cunicularius* with a small aggregation on the face of the exposed dune in E1. This aggregation numbered only a few tens of bees and, as with the ants, the bees were probably deep enough to survive the excavations. *C. cunicularius* is a species that should benefit from this intervention and I will walk the excavated dune areas in the spring of 2014 and attempt to count the burrows (see Appendix B, Photo 10) that are present. The only other aculeates

taken in the pitfalls were single specimens of *Cerceris arenaria*, *Mellinus arvensis* and *Osmia aurulenta* – all on the excavated dunes.

6. Discussion

There are many variables which make it difficult to interpret how invertebrates are responding to the exposure of bare sand in the slacks and dunes faces, including the recent nature of the management work, the difficulty of differentiating between colonization and dispersal events, the lack of control stations and sampling methods. However, it is apparent that several species which are reliant on pioneer conditions have been recorded in the excavated areas, including five key species associated with pioneer dune slack conditions (Table 9). Only *Gabrius osseticus* was recorded from the Control Slack, and in much reduced numbers. Future sampling should help to determine if these species become established on the excavation sites, and where additional pioneer species colonize the areas.

Table 9: Numbers of individuals of the target species for pioneer dune slacks recorded in pitfalls in 2013.

	Control Dunes	Control Slacks	Experimental Dunes	Experimental Slacks	Total
Dyschirius politus	-	-	-	3	3
Bembidion pallidipenne	-	-	-	7	7
Bledius subniger	-	-	-	34	34
Gabrius osseticus	-	2	26	19	47
Dryops nitidulus	3	-	-	9	12

I have discussed the more probable losses and gains of beetle species on the more landward dunes in Loxton (2009) and apart from Table 8 above I see no point in labouring this point further apart from suggesting that future monitoring of this present intervention seems important. This is not only of academic interest but if this sort of intervention should be extended in the future on Newborough Warren or on other dune systems, some data on the possible gains to be achieved can be at least partly known from this sort of monitoring. Even with the extensive effort put into the pitfall trapping, we are only getting a partial view of the nature and abundance of the ground fauna. As noted above, about a quarter of the species reported here were represented by only a single individual. Also, it must be stressed that pitfall trapping is only of value in assessing the relative abundance of each species in different habitats. Even this is open to the criticism that, as the technique is dependent on the activity of the insects, the catch may be disproportionately high in a habitat, such as bare sand, where movement is unimpeded. This is almost certainly the case in the data reported here. Some of the species caught on the surface of the excavated slacks are in an ‘inappropriate’ habitat and are only present fortuitously, running across the bare sand from one patch of suitable habitat to another. To get more statistically robust information, we would need to sample more quantitatively.

It would be possible to take samples of turf or sand and extract all the animals therein. This could yield useful data for some of the smaller animals such as mites, collembola and the smaller beetles. However to get useful data on species with bigger individuals the labour, and habitat destruction, consequent on such a sampling regime is probably unavailable and unacceptable. But if monitoring was limited to bare sand in the excavated slacks and dunes, useful data might be obtained along the lines of the finger searching for fixed periods as in Bratton (2012). The habitat perhaps of greatest interest in this intervention is that of the embryo slack and many of the 'target species' such as the *Bledius* species and their *Dyschirius* predators can be seen on the surface or detected by their burrows. As has been reported here, there seem to be indications that this fauna may have been attracted to the habitat created by the excavations.

7. Recommendations

Irrespective of any future management actions, I will offer to attempt such work in 2014 combined with some night searching on the excavated dunes. The procedure would be to stake out areas for searching and spend a set time finger-searching each plot on several occasions. Should I be available in 2015, I would like to repeat the pitfall survey reported here.

8. Acknowledgements

I am grateful to John Bratton for providing the photographs of the excavation work in progress and the picture of a pitfall trap. Aerial photographs were supplied by NRW. I am grateful to Graham Williams for sending me the aerial photographs and plotting the positions of the trapping sites in Figure 1. Richard Gallon and Chris Felton kindly checked some of the spider material.

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10. Appendices

10.1. Appendix A: Some Additional Observations

In the course of my visits to the study area, I made a few unsystematic observations of the vegetation and fauna of the dunes and excavated areas that may be of peripheral interest as they concern the changing vegetation of the dunes. I was interested in the prevalence of woody scrub on the dunes and whether the ponies were controlling this. For many species it seemed to me on a series of walks that pony browsing was doing a sufficient job of controlling much of the scrub. Clear signs of the biting off of growing shoots even of young Corsican Pine trees can be seen (Appendix B, Photo 11). The other species that seem to be being controlled to a greater or lesser extent by the ponies are Hawthorn, Apple, Birch, Sallow, Ash, Oak (only a few trees near the forest edge), Holly (not common but can be closely browsed) and Elder. However these can 'escape' above the browse line and can provide nesting sites for birds as big as Carrion Crow (Photos 12 & 13) – I found two such nests in small hawthorn trees, without making much effort. Probably in the more seaward areas, wind and salt spray will prevent these trees getting much bigger. Although I made no critical counts, it is my impression that seedling trees are probably being controlled if not killed by the ponies – i.e tree recruitment is being diminished. The ponies have other effects on the bigger trees by using them as rubbing posts. They may use them for shade in summer (Photo 14) and erode the vegetation under the tree.

However there are some species that are not browsed, or not effectively, by the ponies. One of these is Yew but it is not common (Photo 15). Of more importance perhaps are extensive, clonal patches of Blackthorn. This species spreads by underground suckering and in the Penlon area at the edge of the dunes large patches of tall trees have developed. These patches are almost impenetrable for human beings and shade out much ground vegetation. If it was thought necessary to remove these patches on the central dunes I would imagine that excavation followed by spraying would be needed. As aerial photography is easier with modern technology, perhaps these patches and their spread, if any, should be monitored. I have found Magpie nests in some of these patches of Blackthorn in the past. Dogrose is also producing some extensive patches but nothing approaching those of Blackthorn.

I have, in the past, found the odd plant of Sea Buckthorn on the NNR but did not have a GPS device with me then and could not re-find them in 2013. There is a large specimen of *Cotoneaster integrifolius* in the unexcavated part of slack E1 (Photos 17 & 18). There are a few other plants of this species on the dunes close to the forest edge but there seems little indication that it is spreading. The large plant shown in Photo 17 has been there since at least the early 1980s. Although there are two species of invasive *Cotoneaster* in the forest, *C. simonsii* and *C. franchetii*, I have not come across either of these species on the NNR.

It is a constant source of comment and concern that the NNR vegetation is progressing towards closed dune grassland. The author is no botanist but even to my eye there are obvious signs of this progression. When I returned to work on the dunes in 2007, I was struck by the abundance of Hayrattle which I do not remember

as being common in the 1980s. However, without making any proper survey, several plants seem to indicate the progression to grassland. I was struck by finding Cowslip in several places near the intervention site for instance at SH42241 63554 and SH42241 63554 (Photo 19). I have previously seen this plant at the edge of the NNR around the Penlon area but never so far out on the dunes. It was interesting that all these plants were close to pony tracks and are possibly being spread by the ponies in their dung. Bulbous Buttercup (Photo 20) was numerous over wide areas of the more low-lying dunes. There was also a large patch of Meadow Saxifrage (Photo 21) on the high dune ridge between E1 and E2. Oxeye Daisy (Photo 22), though not as common as Bulbous Buttercup, is widespread. No doubt there are many other species that are indicative of the change towards a closed grassland sward that would be apparent to a more systematic survey.

It also seems to me that there are changes in the animal populations that can be observed or inferred. I was struck by how often I saw foxes on my visits to the dunes. Sometimes, if one was down wind, it was possible to watch the animals. From their behaviour they could be judged to be hunting small mammals in the longer grass. Also on almost every day I visited, one could see a kestrel hovering over the dunes. Although both predators take a variety of species, voles are an important prey. Foxes in particular prefer Field Vole to other small mammals and it seems likely that these two predators are exploiting these voles that in turn have increased with the more dense ground vegetation.

Another phenomenon that probably testifies to the increased vegetation was a mass emergence in May and June of at least two species of cockchafers, *Hoplia philanthus* and *Serica brunnea*. The insects were so numerous that for several days they attracted a flock of non-breeding and juvenile gulls. The gulls hunted the beetles on the ground and in the air. I also noted that the gulls used the excavated slack area of E1 as a ‘club’ site – this term was coined by N. Tinbergen in his book, *The World of the Herring Gull.* During May and June, as many as 50 birds roosted or rested on the slack in the middle of the day. It is not known whether the excavated slack was particularly attractive to the birds.

These casual observations are of interest to the observer but, due to their unsystematic nature, are of little value in helping to formulate future management of the dunes. I know there is a regular butterfly census and that an annual breeding bird transect is undertaken. The Warden Graham Williams had noted Chifchaff on the dunes, a sure indicator of scrubby land. A very obvious species was Stonechat, with the males singing from the tops of bushes. Should not an attempt be made to make a census of species such as Skylark and Meadow Pipit?

10.2. Appendix B: Images of Newborough Warren

Photo 1: Excavation in progress in Slack 2 (E1 in this report) 11th March 2013.

Photo 2: Slack E1 21st March 2013. Note the 'island' of slack vegetation remaining in the middle ground, retained for its bryological interest and to act as a spore reservoir for the excavated areas. Site E1S1 had to be placed just in front of this 'island' but, as the slack dried out, was moved closer to the camera position.

Photo 3: E1 8th June 2013. Note that the slack is still shallowly flooded. The small piles of sand around the edge of the slack have been eroded by wind – cp. Photo 2. Note also the extensive sand churning by ponies in foreground, on the dunes to the right and at the edge of the open water in the slack. The photo is taken approximately from the position of trapping site E1D2.

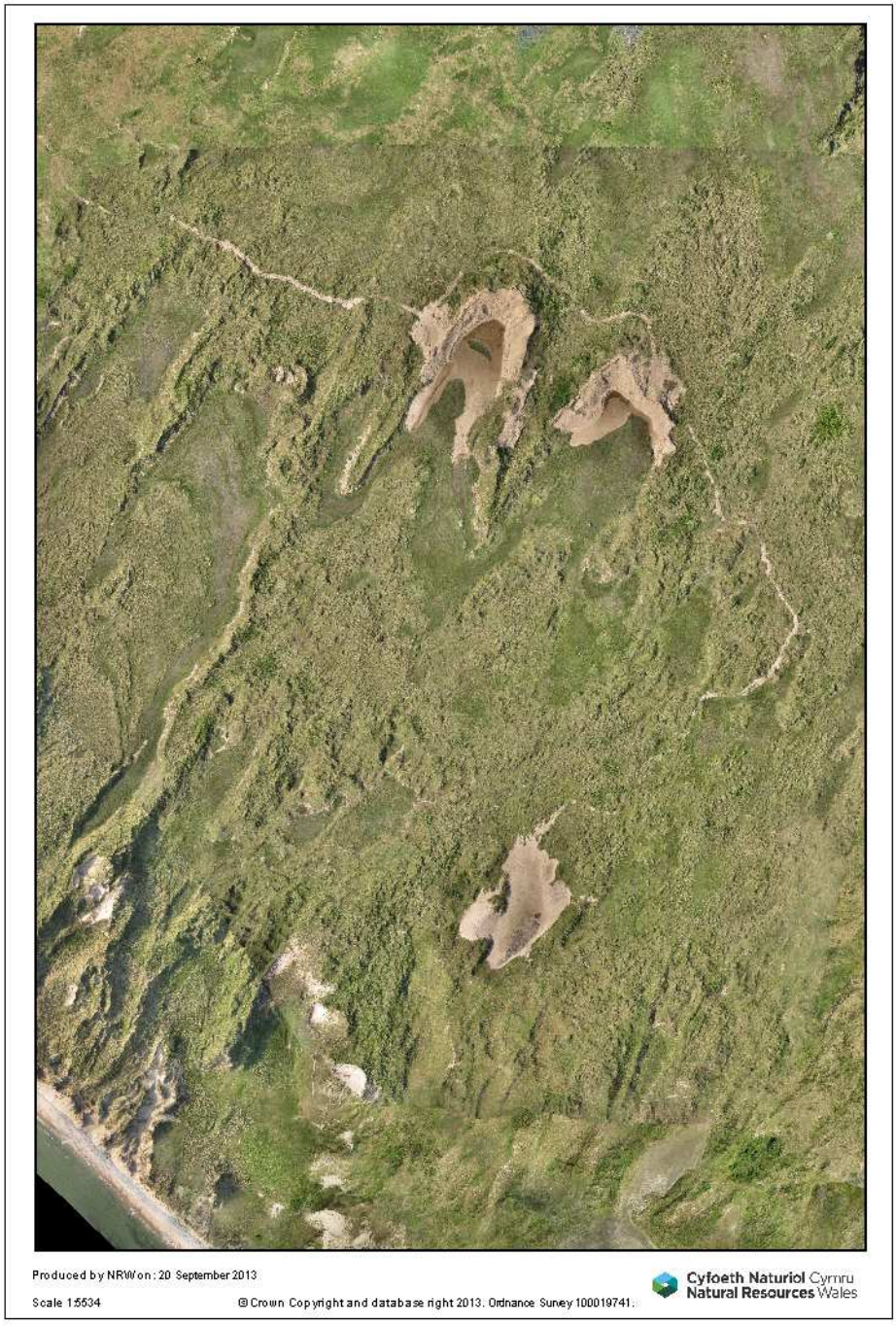

Photo 4: Aerial photograph of the excavated slacks and the control slack. The excavated slacks monitored here are in the upper half of the photograph (originally designated Slacks 2 & 3). To their immediate left and slightly downwards is the Control Slack (originally designated Slack 1).In the middle towards the bottom of the photograph is the other excavated slack, Slack 4, which was not sampled during this survey.

Photo 5: View of pitfall trap on excavated dune (E2D3) September 2013. Note some sand around edge of the filter. Also note the regenerating Marram Grass.

Photo 6: Habitat in the vicinity of trapping site CD1 (dunes on the northern edge of the Control Slack).

Photo 7: Habitat near trapping site CD2. Dunes at the head of the slack.

Photo 8: Habitat and pitfall in the control slack at CS3.

Photo 9: A view of Excavated Slack 1 in May 2013. In the foreground to the right is the small 'island' of slack habitat left by the excavations. This 'island' can be seen in Figure 1 and Photo 4. E1S1 was near the edge of the water, bottom right. The trapping site E1D2 was about half way up the dune face in the background.

Photo 10: Characteristic burrow of *Colletes cunicularius* near trapping site ED2, 22nd May 2013. Note exposed roots of Marram Grass.

Photo 11: Young pine tree browsed to death by ponies.

Photo 12: Carrion Crow's nest and chicks, 22nd May 2013, SH 42376 63554. The small tree in which this nest was made is shown in Photo 13.

Photo 13: Small Hawthorn Tree that held a Carrion Crow's nest (Photo 12).

Photo 14: Corsican Pine and Sallow used for shade and rubbing. The Sallow is almost dead. Although this photograph was taken near the forest edge, there are similar examples in the middle of the dunes.

Photo 15: A Yew (middle) and Hawthorn on perhaps the highest dune on the NNR.

Photo 16: In the middle ground an extensive (approximately 50m by 40m) patch of Blackthorn at SH 4250 6336 in the centre of the dunes. This patch of Blackthorn held a breeding fox earth.

Photo 17: A large specimen of *Cotoneaster integrifolius* at SH 42015 63293 in E1.

Photo 18. Flowers of *Cotoneaster integrifolius*.

Photo 19: Cowslip at SH42241 63554.

Photo 20: Bulbous Buttercup. This species is very abundant over large areas of the dunes.

Photo 21:.Meadow Saxifrage. A large patch was noted at SH42166 63367. No other patches of this species were found in the central dunes near the intervention site.

Photo 22: Oxeye Daisy at SH4248 6315.

10.3. Data Archive Appendix

The data archive contains:

[A] The final report in Microsoft Word and Adobe PDF formats.

[B] Species records, which are held on the NRW Recorder 6 database.

Metadata for this project is publicly accessible through Natural Resources Wales' Library Catalogue http://194.83.155.90/olibcgi by searching 'Dataset Titles'. The metadata is held as record no 115702.

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