Report

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Upland pony grazing: A review

Sophie Lake

Forest Office
Cold Harbour
Wareham
Dorset BH20 7PA
Tel/Fax: 01929 552444
info@footprint-ecology.co.uk

connecting wildlife and people
www.footprint-ecology.co.uk

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Summary

There is concern over the decline in numbers of ponies on Dartmoor's moorland and the resulting implications for the Moor's ecology. This concern led Dartmoor's Pony Action Group to commission a review of the literature relevant to the role of pony grazing on moorland habitats in order to provide evidence on the effects of pony grazing on the management of upland vegetation, and to inform the debate on the role of ponies within agri-environment schemes. Of particular interest was any information regarding potential differences between pony grazing and that by other livestock types present on Dartmoor. This report documents the results of that review, which may also be relevant to other uplands areas in the UK.

There is little literature available concerning the role of pony grazing in the uplands; most research has been focussed on the impacts of cattle and sheep. There is, however, a body of work from the lowlands, notably the New Forest and the Dorset Heaths, and also one significant project from Dartmoor itself. Thirty-nine relevant papers, books and unpublished reports were reviewed, although many of these relate only tangentially to pony grazing on Dartmoor.

The literature reviewed suggests that, like cattle and sheep, ponies strongly prefer grassy habitats within moorland mosaics; however:

- Ponies are likely to have more of an impact in wet heath, valley mire, gorse brake and Bracken-dominated communities than cattle and sheep.
- Ponies may have slightly less of an impact on dry heath through grazing and trampling
- Habitat selection by ponies is less likely to be influenced by the location of supplementary feed or water than cattle.
- Ponies are likely to be more widely dispersed and travel further than cattle, resulting in a more diffuse impact, and are likely to use a wider range of habitats.
- Ponies are more adaptable than other livestock types, showing more seasonal variation in habitat use and diet.
- Overall, ponies may make a valuable contribution to cattle and sheep grazing through creating varied and species-rich vegetation and benefitting the animals dependent on this; however there is as yet little direct evidence available.

The knowledge gaps that need to be addressed to allow the role of ponies in the ecology of Dartmoor to be more fully assessed were identified as:

- The actual impacts of pony grazing on Dartmoor, including on invertebrates and breeding and wintering birds in addition to vegetation;
- Site specific use of habitats and features on Dartmoor, and seasonal variation in this;
- Dispersal of ponies compared to cattle and sheep on Dartmoor;
- The interaction between pony, cattle and sheep grazing on Dartmoor.

Contents

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1. Introduction

Context of the review

1.1 This review of the role of ponies in the ecology of Dartmoor was commissioned by Dartmoor's Pony Action Group[1] following concern raised at a meeting of Commoners Associations in January 2015 over the failure of agri-environment schemes to recognise the contribution to vegetation management provided by ponies. Dartmoor has been grazed by cattle, ponies and sheep for centuries. Until relatively recently, most Dartmoor farmers ran a herd of ponies on the moor. However, the number of ponies on Dartmoor has declined over the last 100 years. The number of ponies present at any one time is much debated, but 30,000 were reported seventy years ago and 2,000-6,000 in the 1960s (Petrie-Ritchie 2015). Today, estimates provided by the Dartmoor Commoners' Council, the Dartmoor Hill Pony Association and the Dartmoor Pony Heritage Trust and are of 1,000-1,200 Dartmoor ponies, of which 350 are pedigree or heritage type.

1.2 Reductions in the number of ponies in Dartmoor during the 21st century are thought to be a consequence of changes in export laws in 2007, which reduced the market value of unhandled ponies. Despite efforts to bolster alternative markets within the UK, the changes have resulted in farmers reducing the size of their herds and the widespread culling of unwanted young ponies (Petrie-Ritchie 2015). In addition, since 2011, the agri-environment schemes under which most of the Dartmoor commons are managed offer payments explicitly for cattle grazing, but rarely for pony grazing. As a consequence, there is little incentive for farmers to graze with ponies, given that they can receive payments for, and sell the offspring of, cattle. A reduction in overall stocking rate, generally required by moorland agri-environment schemes, is more likely to have been achieved through a reduction in the number of ponies and sheep than of cattle.

[1] Dartmoor's Pony Action Group can be contacted through the Dartmoor National Park Authority.

1.3 The (registered) pedigree Dartmoor pony is classified as being an endangered native breed by the Rare Breeds Survival Trust[2]. In addition to concerns about the decline of an endangered breed, and of the rich cultural heritage associated with it, there are concerns that the loss of ponies may impact on the nature conservation interest of Dartmoor. For example, on Dartmoor, ponies are often grazed on small pockets of habitat that are marginal to the farm business but of significant nature conservation interest (e.g. supporting populations of the rare Marsh Fritillary butterfly *Euphydryas aurini*). Cattle grazing on such areas is not always economic, due to access constraints, poor quality forage and boggy ground, and without ponies, these areas might be ungrazed (J. Plackett, pers. comm.). The ecological characteristics of Dartmoor pony grazing may mean that ponies play a unique role in the nature conservation of Dartmoor. However, this role is not currently fully understood.

1.4 This report was commissioned in the context of Dartmoor. However, results of this review of the role of ponies in moorland will potentially be useful in other parts of the country.

Potential impacts of grazing

1.5 Direct impacts of livestock on species and the heathland habitat may arise through feeding, trampling, poaching, dung and urine deposition, dispersal, erosion and through human activities associated with managing livestock (Lake, Bullock & Hartley, 2001). Many impacts on species are indirect, leading on from habitat changes caused by grazing. At an appropriate level, grazing may enhance species diversity and the structural diversity of the vegetation, and help prevent natural succession to other habitat types.

1.6 Although there is a body of work looking at the impacts of livestock grazing on heathland (see reviews by Martin *et al.* 2013 and Lake, Bullock & Hartley, 2001), there is very little published specifically on the impacts of pony grazing. This review therefore focusses on the behaviour of free-ranging ponies in semi-natural sites and discusses this in terms of its implications for nature conservation.

[2] http://www.rbst.org.uk/Our-Work/Watchlist/Watchlist2

1.7 The areas of pony behaviour considered to be of particular relevance in terms of the potential impacts on habitats are:

- Habitat use, including overall preference, behaviour in different habitats and seasonal differences;
- Foraging behaviour including selection of key species such as Purple Moor-grass *Molinia caerulea*, Heather *Calluna vulgaris*, gorses *Ulex* spp. and seasonal changes;
- Other behaviour such as herding, use of shelter, rolling, use of latrines, attitude to supplementary feed;
- Interactions between livestock species.

1.8 It is known that herbivores are selective in their use of habitats and their choice of plant species (e.g. Jarman & Sinclair 1979; Duncan 1983; Grant *et al.* 1985, 1987; Gordon 1989a). Within an extensive area of semi-natural vegetation that encompasses a variety of habitat types, habitat section will be due to herbivores' foraging strategy. This is determined by physiological factors and social behaviour, which vary between species and breeds. It will also depend on environmental factors such as climate, topography and human disturbance, in addition to the abundance and availability of forage, and will therefore vary between sites.

1.9 These factors are summarised below, based on a review by Lake, Bullock and Hartley (2001). This sets the context for the review of habitat use and behaviour by ponies in semi-natural upland habitats (with particular reference to Dartmoor) and comparison with other livestock that follows in the rest of this report.

Physiological factors likely to lead to behaviour differences between ponies and other livestock grazing on Dartmoor

Physiology

Because of their digestive strategy, ponies are likely to eat more than cattle and sheep. To keep up their intake, they are less selective and will eat more poor-quality forage.

1.10 Domestic herbivores are either hind-gut fermenters (e.g. ponies) or ruminants (e.g. cattle, sheep and goats). Equines (horses, ponies, mules and donkeys) generally have a higher rate of food intake than a similarly sized ruminant, and this more than compensates for their lesser ability to digest plant material (Duncan *et al.* 1990), although they may need to eat more poor-quality (i.e. more fibrous) forage to keep up their intake. Their energy requirements are also slightly higher. However, they are more able gain nutrition from dead material, and so are less likely to experience winter

nutrient stress. For example, Van Wieren (1991) found that Shetland ponies lost a smaller proportion of their bodyweight than Highland cattle when overwintering on a conservation site in the Netherlands. This difference is also demonstrated in the New Forest, where ponies are traditionally out-wintered but the majority of cattle are removed (e.g. Ekins 1989).

1.11 Within ruminants, there is a gradient between species whose gut morphology is adapted to browse (such as deer) and those adapted to graze (e.g. cattle and sheep) (Hofmann 1989). Grazers retain forage within the rumen for longer, enabling the breakdown and use of the contents of the plant cell walls; browsers have a short retention time and exploit the more rapidly digestible cell contents, which means they must be more selective. Equines are generally grazers, although they may browse a little.

Body Size

Smaller animals need better quality forage than large ones.

1.12 The relationship between metabolic rate and body size makes body size another important determinant of how herbivores graze. Smaller animals have a greater metabolic rate per unit body weight than larger ones. This means they need better quality forage. Larger animals must still intake a larger quantity of forage, but their lower metabolic rate plus the longer retention time within the rumen means they can use forage of lower quality (e.g. Jarman & Sinclair 1979; Demment & Van Soest 1985; Illius & Gorson 1992). This is seen in the difference between sheep and cattle; work by Grant *et al.* (1985) found that cattle were more likely to graze more fibrous elements of the swards than sheep.

1.13 The relationship between body size and metabolic rate can also lead to different habitat choice between sexes in dimorphic species (those species where males and females are usually of different sizes) and has been observed in, for example, Red Deer *Cervus elaphas* (Osborne 1984).

Muzzle morphology

Ponies can graze (and create) a shorter sward than cattle as they have opposing incisors.

1.14 Incisor morphology is also important. Ponies have powerful opposed incisors that can easily cut through fibrous stems (Van Wieren, 1991). In ruminants, the lower incisors close obliquely against a hard palate and tear vegetation rather than cut it. Ruminants also use their tongue to wrap around vegetation and

pull. These differences allow ponies to graze closer to the ground and create a shorter sward than larger ruminants such as cattle. However, smaller ruminants with finer muzzles such as sheep are able to graze more closely than cattle, and are also able to be more selective in fine-scale mixtures (Grant *et al.* 1985; Grant *et al.* 1987).

1.15 Larger animals also have a smaller incisor breadth in relation to their metabolic requirements. This means they have a small bite size relative to their overall body size, and so must graze on swards that allow a greater intake of forage per bite. Smaller animals can rely on shorter swards from which larger animals may be displaced as food becomes limited.

Inter-specific interactions

Indirect competition may cause one livestock type to displace another from a particular area.

1.16 On sites with more than one species of livestock grazing, such as Dartmoor, inter-specific interactions may have an impact on habitat selection if resources become limiting. Once a sward has become sufficiently depleted that only smaller animals are able to exploit it (see Body Size and Muzzle Morphology above), large animals such as cattle and ponies are forced to move to areas where forage is still easily available. This was observed on Rhum (Gordon, 1989), where Red Deer (and ponies) displaced cattle onto more nutrient poor grassland when the preferred sward of more easily digestible species had been grazed down in winter. On the nutrient-poor sward (Purple Moor-grass *Molinia caerulea*/Black Bog-rush *Schoenus nigricans*), cattle were able to take a larger amount of forage, although its nutritional status was lower. The opposite has also been observed, with the removal of sheep from upland heathland in Scotland resulting in an increase in the number of wild Red Deer.

1.17 Direct competition (i.e. one species directly preventing another from grazing, for example by chasing it away) has rarely been reported between domestic livestock species grazing extensively on semi-natural habitats.

Differences in husbandry

Physiological differences are reflected in husbandry, e.g. ponies are more commonly out-wintered than cattle.

1.18 The importance of these physiological differences is seen in typical husbandry practices. In general, hardy breeds of ponies are out-wintered on extensive heathland sites such as Dartmoor, Exmoor, and the New Forest and on numerous smaller heathland sites. In contrast, cattle are often brought under cover during the winter or onto improved land closer to farms. This is not always the case, and cattle may be successfully out-wintered on upland and lowland sites (e.g. see the Morecombe Bay Conservation Grazing Company[3]). In such situations cattle are generally provided with supplementary feed, at least in harsh weather conditions. The provision of supplementary feed for cattle (to ensure weight gain for sale, which is not a requirement for ponies) can lead to poaching at feeding sites.

1.19 In some cases, such as the New Forest, out-wintered cattle may return to the farm at night. This means that, even when present during the winter, they are likely to be less widely dispersed than ponies (e.g. Pratt *et al*. 1986).

2. Methods

2.1 The use of a strict evidence-based review protocol (e.g. Stone 2013) was not appropriate in this situation. There is very little published literature available directly relating to the impacts or behaviour of ponies on upland habitats, and the aim of this review was to ascertain what is known rather than to examine the evidence base for specific assertions or grazing management practices. The process used was as follows:

1. Published literature was searched for via Google Scholar using the following search terms: (conservation+grazing+pony; conservation+grazing+horse; free-ranging+pony+behaviour; feral+horse; Dartmoor+pony; Dartmoor+grazing)
2. Published and unpublished 'grey' literature was searched for within the Footprint Ecology reference database (7000+ references, within which conservation grazing is a key topic); on the internet using Google; by asking key researchers identified

[3] http://www.grazinganimalsproject.org.uk/gap_site/morecambe_bay_local_grazing_scheme.html

through step 1, and by asking conservation graziers and other professionals with an interest in conservation grazing (e.g. Natural England specialists);

3. Literature identified was initially screened for relevance, and copies obtained of the most useful material. These were assessed in terms of robustness and applicability (e.g. publications status, experimental or observation, replicated or not, statistically analysed or not), and relevant findings extracted and stored within a spreadsheet according to topic (references used and a brief summary of each are found in Appendix I).
4. Anectodal information was requested via the online conservation grazing forum Nibblers[4]

2.2 The information obtained is used to describe aspects of pony behaviour that potentially impact on moorland habitats in Section 3. This is set within the context of the behaviour of sheep and cattle, about which more is generally known, to provide an assessment of the extent to which the role of ponies grazing in upland habitats may be unique.

2.3 The term "Dartmoor pony" as used in this report refers to pedigree "registered" Dartmoor ponies (registered by the Dartmoor Pony Society and recognised by the Rare Breed Survival Trust), unregistered "heritage" ponies that nonetheless fit the traditional Dartmoor pony type and "hill" ponies. It does not include ponies on Dartmoor that are clearly of a different breed, such as Shetland ponies, which are referred to separately where relevant.

RESULTS OF REVIEW

3. Information available

There is little published work on pony grazing in the uplands.

3.1 The only substantial work found that specifically looks at the behaviour of Dartmoor ponies on Dartmoor is the unpublished work by Freshney (2001), although there are a handful of other, smaller studies (e.g. Baldock 2010; Petrie-Ritchie 2015).

[4] https://groups.google.com/forum/?hl=en#!forum/nibblers

There is a substantial body of work on upland grazing from Scotland, but this mostly concerns cattle and sheep.

3.2 There is a relatively large body of published work examining habitat selection and foraging behaviour in the Scottish uplands (notably the work done by the James Hutton Institute and its predecessor bodies). In general, it covers cattle and sheep grazing only. However, there is some useful information from a project comparing different herbivores, including ponies, on Rhum (Gordon 1989b). A review of upland overgrazing by Hester (1996) and a more recent review on upland grazing and stocking rates by Martin *et al.* (2013) both examine this work from Scotland in some detail (and in some cases we refer directly to the review by Martin *et al.* rather than re-examining the source material).

3.3 There is also a body of work exploring livestock grazing on upland heathland mosaics in Spain. Some of this work includes the behaviour of ponies (e.g. Ferreira *et al.* 2013; Celaya *et al.* 2011).

Most work on pony grazing has been carried out on lowland heathland.

3.4 The largest body of work on pony grazing is from lowland heathland. This includes research on the behaviour of ponies and cattle in the New Forest by Putman and colleagues (e.g. Putman *et al.* 1984, 1987; Pratt *et al.* 1986); on behaviour and body condition of New Forest ponies (e.g. Tyler 1972; Pollock 1980; Gill 1987) and on pony and cattle behaviour and impacts on the Dorset Heaths (Lake 2002). There is also research on equines grazing on non-heathland habitats, and this has been considered in this review where it is of sufficient relevance (e.g. Duncan 1983; Fleurance, Duncan & Mallevaud 2001; Loucougaray, Bonis & Bouzille 2004; Lamoot, Meert & Hoffmann 2005; Rigueiro-Rodríguez *et al.* 2012).

4. Habitat use

Overall habitat selection

Context

Livestock free-ranging in extensive heterogeneous sites show distinct preferences for particular habitat types. This is often dictated by the availability of preferred forage.

4.1 Herbivores generally show distinct preferences for particular habitat types when free-ranging in habitat mosaics. In the uplands, livestock are known to use habitats unevenly (Martin et. al 2013), with a strong preference for areas that support the grassy vegetation preferred for foraging. For example, in Spain, Ferreira *et al.* (2013) found that ponies, cattle and sheep all spent more time on pasture than the adjacent gorse and heather vegetation. Such preferences may be dictated by the availability of preferred forage, but it will depend on individual site characteristics and the breed, background and established routine of the livestock (factors influencing habitat selection are discussed in the following section).

Ponies

Ponies strongly prefer grassy habitats.

Ponies also use dry and wet heath, valley mire, gorse brake and woodland but this is varies between sites and use is generally not in proportion to the amount of habitat available.

4.2 Ponies show a strong preference for grassy habitats. In the New Forest, where extensive areas of lowland heathland are interspersed with areas of woodland, improved grassland and streamside grassy 'lawns', ponies were recorded on grassland in 35-67% of observations (Pratt *et al.* 1986). They showed a strong preference for streamside lawns. On Exmoor, Baker (1993) similarly found that Exmoor ponies showed a preference for habitats with a high proportion of fine grasses, often adjacent to streams. New Forest ponies also used wet and dry heath, valley mire, acid grassland and gorse brake and, particularly at night, woodland. Non-grassland habitats were generally used less than would expected if use was based on area (Pratt *et al*, 1986).

4.3 On Dartmoor, Freshney (2001) found that Dartmoor ponies used dry heath in proportion to its extent, but suggested that a positive preference would have been recorded for fragmented, grassy heath had this vegetation type been recorded separately from dry heath. On a site that included woodland (the Dart valley), ponies were only very rarely recorded within the wood, and there was no evidence (i.e. dung) of pony presence within the woods. There was a little dung on woodland paths and an area of floodplain pasture. Within an enclosed area of Purple Moor-grass and rush pasture with small

amounts of other habitat, ponies were observed using a valley mire in addition to the Purple Moor-grass and rush pasture, although they avoided areas of quaking bog. They appeared to avoid more improved grassland towards the periphery (Freshney, pers. comm.).

4.4 Data from other habitats suggest a similar preference for grassy vegetation. Shetland ponies grazing scrub-dominated sand dunes spent more time on grassland and less time in woodland and scrub than cattle (Lamoot, Meert & Hoffmann 2005). They also grazed more on short swards. Similarly, horses grazing wet grassland in France were found to spend about 70% of their feeding time on short grass lawns where the sward was less than four cm high – such areas represented only 10% of the site (Fleurance, Duncan & Mallevaud 2001). On Rhum, (Gordon 1989c) found that Highland ponies preferred grassy habitats and generally avoided dry and wet heath, and also blanket bog. In a forestry restoration area on Dartmoor, Baldock (2010) found that ponies made greater than expected use of grassland and rush-dominated areas, with less than expected use of heather-dominated and regenerating coniferous woodland.

4.5 On lowland heathland sites in Dorset, New Forest ponies showed a significant positive preference for acid grassland (including road verges) and areas of restoration heath that comprised a matrix of heather and short grassland (Lake 2002). Exmoor ponies also showed a positive preference for grassy habitats (although they avoided road verges, possibly being less tolerant of traffic than the New Forest ponies). Ponies generally used valley mire, wet heath and dry heath less than would be expected according to the extent of the habitat available. However, in this study dry heath was broken down according to the growth phase of the heather (building, mature and degenerate) and it was found that ponies positively selected building dry heath. The habitat type used most in relation the area available was heathland tracks. These supported very short dry heath and acid grassland interspersed with bare ground.

Different pony breeds may vary in how they use sites, but evidence is lacking for this.

4.6 There may be differences between pony breeds. For example, on Dartmoor, Freshney observed that Shetland ponies tended to use the grassland in a way more similar to cattle than to Dartmoor ponies, concentrating on the grassy slopes around tors (Freshney, pers. comm.). They are also less likely to go into tussocky boggy areas, perhaps because of their small size, and seem more likely to remain on shorter, accessible swards (Freshney pers. comm.). A difference was seen in the use of roadside verges by New Forest and Exmoor ponies in Dorset as described above, although this could have been due to the previous experience of the ponies rather than breed.

Cattle

Cattle may show an even stronger preference for grassy habitats than ponies.

4.7 In the New Forest, cattle, like ponies, were found to preferentially graze on grassy habitats (Putman *et al.* 1987) and 60-70% of cattle observations were on grassland (Pratt *et al.* 1986). Cattle showed a stronger preference for improved grasslands than ponies. Similarly, cattle were observed to graze fertile rye-grass swards more heavily than horses within coastal wet grassland sites in France (Loucougaray, Bonis & Bouzille 2004). In the New Forest, cattle used a narrower range of habitats than ponies. They used dry heath and woodland (10-20% of observations on both) but made less use of wetland habitats than ponies and rarely used dense gorse brake. Cattle made slightly greater use of dry heath than ponies at some times of year (Pratt *et al.* 1986).

Cattle are generally likely to make less use of wet habitats, gorse brake and woodland than ponies but may make more use of dry heath.

4.8 In the New Forest, diurnal difference were more noticeable in cattle than ponies, with cattle spending the daylight hours on grassland but more likely to move off into other habitats at night.

4.9 Despite the differences noted between cattle and ponies in the New Forest, the overlap in habitat use was 78% (Pratt et al. 1986).

4.10 At two heathland sites in Dorset, cattle showed similar preferences to ponies, with a significant positive selection for acid grassland and for dry heath in the building phase but also, on one site only, for degenerate heath. Overall, they avoided mature dry heath, wet heath, valley mire and scrub (i.e. used less than would be expected if use was in proportion to the area available) (Lake 2002).

Sheep

4.11 Like cattle and ponies, sheep show a strong preference for grassy vegetation (e.g. Martin et al. 2013). However, sheep do graze heathland, particularly in the years immediately after a burn when the sward is still short. On Exmoor, Baker (2003) observed that sheep preferred open grassland and, unlike ponies, did not use areas with a light bracken canopy. However, on Dartmoor, sheep have been observed to graze grasses under a bracken canopy, although they probably have less impact than ponies (Freshney, pers.comm.).

Seasonal differences

Habitat use is likely to change seasonally as resource availability and the need for shelter changes. Seasonal changes vary between sites and livestock types.

4.12 Habitat use by free-ranging livestock varies seasonally. The range of habitats used tends to reduce in the winter (e.g. Gordon 1986). The extent to which different habitats are used also varies (e.g. Putman, 1996; Pollock 1980). Such changes may be dictated by relative forage availability, and will therefore affect livestock species according to their physiology. However, changes in habitat selection may also be related to the need for shelter or to the contraction in range often seen in winter (see para 5.7 onwards on other factors influencing livestock behaviour). Seasonal variation will itself be different according to the composition of the site and the livestock type (including species, breed, gender and background).

Habitat use by ponies changes seasonally, but this can vary between sites and between breeds on the same site.

4.13 On Dartmoor, ponies spent more time in Bracken in autumn (Freshney 2001), possibly because this is when grass and Bramble was revealed as the Bracken died back. However, there was little other evidence of seasonal variation. Freshney suggested that this was due to the hardiness of Dartmoor ponies or to the terrain and distribution of woodlands. Cattle also use Bracken in autumn on Dartmoor (Freshney pers.comm.) but their impact on Bracken may be more limited as under agri-environment schemes they may be taken off the moor in early autumn (Freshney, pers. comm.).

4.14 In the New Forest, ponies spent more time in gorse brake and woodland in the winter, presumably for shelter (Putnam *et al.* 1987). However, in a study on lowland heath on the Isle of Wight, New Forest ponies positively selected gorse brake and avoided dry heath in the winter on one site but positively selected dry heath and avoided woodland on another, suggesting there is an

interaction between the need for forage and for shelter (Perera & Goodwin 2004).

Ponies often make greater use of gorse brake and grasslands in winter.

4.15 On Hartland Moor in Dorset, New Forest ponies made greater use of restoration heath (a mosaic of dry heath and acid grassland) in winter, while Exmoor ponies made increased use of acid grassland. However, both breeds showed an increase in the use of habitats with a grassy component in winter. They also made more use of dry heath in the building phase in summer. Similarly, New Forest ponies made more use of regenerating heath in summer (Pratt *et al.* 1986).

4.16 Data from the New Forest suggest that seasonal variation may depend on the type of grassland. Pratt *et al.* (1986) found that the use of improved grassland increased in winter, while the use of reseeded grasslands and streamside lawns decreased (although use still remained higher than would be expected according to the extent of the habitat). Overall, grassland use by ponies in the New Forest peaked in spring, coinciding with a peak in feeding activity. On Exmoor, Baker (1993) found that the preference for grassy streamside vegetation was greatest in dry summers.

Ponies make more use of wet heath, valley mire and regenerating heath in summer.

4.17 Results from several studies suggest that an increase in the use of wet heath and valley mire is likely in the summer months. On Rhum, Highland ponies that generally avoided wet heath used it during the period in which Purple Moor-grass was growing (Gordon, 1989). A similar trend was observed in Dorset where ponies made significantly greater use of valley mire and wet heath in summer, in some cases positively selecting these habitats (Lake 2002). This was generally associated with a decline in the use of grassy habitats, which were droughted by July and August. Data from the New Forest again partially supports this, showing increasing use of wet habitats in summer. Putman *et al.* (1987) suggest that these changes could be a result of drought and the higher numbers of stock out in the forest in the summer, meaning that resources are limited on the preferred grasslands.

Cattle also maintain a strong preference for grassland in winter, but in some circumstance may be forced to move onto habitats with more abundant vegetation of lesser quality.

4.18 Cattle on the island of Rhum in Scotland showed contrasting behaviour. In autumn and winter they selected nutrient-poor grassland, Purple Moor-grass and Black Bog-rush fen, wet heath and blanket bog, while ponies and deer remained on mesotrophic (i.e. of moderate fertility) grassland communities. Gordon suggested that cattle moved onto longer swards when the mesotrophic grassland was grazed right down by other livestock (as would be predicted by their larger size and lack of opposing incisors).

4.19 In Dorset, cattle use of wet heath and valley mire increased in summer, although these changes were not statistically significant (Lake 2002). Cattle made more use of road verges in autumn (data were not available for winter, when the cattle were removed). Changes in the use of acid grassland by cattle varied between sites. In the New Forest, cattle showed little seasonal variation compared to ponies (Pratt et al. 1986). Use of dry heath remained fairly constant throughout the year (Putman *et al.* 1987) but cattle preference for grassland peaked in summer.

Diurnal habitat selection may change seasonally, e.g. increased daytime use of woodland in winter

4.20 Diurnal variation in habitat use may also change seasonally. For example, In the New Forest, ponies hardly used woodland in daylight hours in the summer, although they used them for foraging at night, However, in the winter they also used woodland for daytime feeding (Pratt *et al.* 1986).

Sheep are less likely than cattle to move onto Purple moor-grass or Mat-grass swards in summer. Use of heather-dominated areas is highest in winter.

4.21 Habitat use by sheep also shows seasonal variation, and again varies according to the vegetation type. Studies have shown use of reseeded grassland and bent/fescue grassland peaks in May-June, and remains high for bent/fescue until October, but drops after June for reseeded. Use of heather is highest in winter and purple moor grass in July. However such trends depends on grazing density and make up of individuals sites (Martin *et al.* 2013). Sheep were found to be less likely than cattle to move onto Purple moor-grass or Mat-grass swards in summer (Armstrong 1996).

4.22 Baker (1993) states that studies on Dartmoor suggest sheep, ponies and cattle have different preferences for vegetation type; however this is not referenced.

5. How behaviour and other factors influence habitat use

The role of foraging in determining habitat selection

For ponies, foraging is the main behaviour in most habitats. Pony dispersion may therefore be more determined by forage availability.

5.1 Foraging is likely to be the key behaviour carried out in most habitats by ponies. Ponies spend most of their time foraging (e.g. Duncan 1983), even more so than cattle (e.g. Pratt et al. 1986, Lake 2002). In a study of free-ranging horses in the Carmargue, Duncan (1983) found a positive relationship between habitat use and abundance of green (as opposed to dead) vegetation. In contrast, Putman *et al.* (1987) found no clear correlation between forage availability and habitat use in cattle and ponies in the New Forest, although habitat use was not random; grassy habitat were preferred. However the availability of forage was considered to dictate pony distribution in summer while shelter influenced winter distribution.

Ponies spend more of their time foraging than ruminants, and continue to forage throughout the night.

5.2 Ponies graze for a high proportion of the day and night. In the New Forest, ponies grazed for up to 75% of the time during which recording took place (Pratt et al 1986). Wild Przewalski horses spend 70% of their time grazing. In the Camargue, ponies were recorded foraging for 55-65% of their time (Duncan 1983). Grazing bouts are interspersed with relatively short resting periods. Lake (2002) found that the longest resting period (about two hours) was at night, but that ponies continued grazing after dark.

5.3 Time spent foraging may vary seasonally. For example, Welsh pony stallions show energy saving adaptations in winter with a reduction in active behaviours, including foraging. Eating increased in the spring, and decreased again in summer, although in summer activity levels remained high (Morel *et al.* 2006).

In wet habitats and grassy habitats ponies spend the majority of their time foraging.

5.4 Lake (2002) examined behaviour in different habitats for New Forest ponies and Exmoor ponies on a lowland heathland complex in Dorset. Results were similar for both pony breeds, although differences between habitats were slightly more pronounced in Exmoor ponies. In wet habitats (wet heath and valley mire), ponies spent significantly more time on foraging than on other activities. The time spent foraging was also greater in grassy habitats.

Cattle spend less time foraging than ponies and have more clearly defined resting periods, including overnight. Factors other than foraging may be more important in determining habitat use by cattle.

5.5 Cattle are ruminants, so spend less time grazing than ponies. Lake (2002) found that cattle grazing the Dorset heaths tended to have three main foraging bouts in 24 hours interspersed by periods of rest and movement. Each foraging bout was generally in a different area, often in a different habitat, meaning that cattle travelled between foraging bouts. Short periods of foraging also occurred in the main overnight resting area during the night. In the New Forest, cattle fed for 57% of the time (mostly during the day) spending much of the remainder resting or ruminating (Pratt *et al.* 1986). For cattle, foraging is therefore less likely to be the key behaviour in all habitats.

5.6 Lake (2002) found that cattle spent the majority of their time foraging when on acid grassland at one heathland site, although at a second site they spent more of their time on acid grassland resting. Like ponies, they spent most of their time in valley mire and wet heath foraging. In other habitats they spent more time resting.

Other factors influencing habitat selection

5.7 The availability of forage is not always the key determinant of habitat use (e.g. Putman et al. 1987). Other factors which may influence habitat selection in domestic herbivores and their impact on vegetation include herding behaviour, the location of water and shelter, and behaviours such as rolling and 'shading'. This section explores the information available on how pony behaviours other than foraging influence habitats use, and compares this to other livestock species where possible.

5.8 Free-ranging livestock tend to follow an identifiable daily routine, although this varies over time and may be seasonal. It may be also influenced by human activities, such as supplementary feeding or by people offering titbits. It varies between livestock types.

Herding and ranging behaviour

5.9 Herding behaviour influences the dispersion of animals across habitats, and can influence habitat choice.

Ponies

Free-ranging pony behaviour is influenced by the presence of stallions, who maintain harems.

5.10 Free-ranging pony herding behaviour is influenced by the presence or absence of stallions. Wild horse populations with natural sex ratios generally have a harem structure (e.g. Wells & von Goldschmidt-Rothchild 1979). This is the case on Dartmoor and Exmoor, where stallions are generally still run with mares. On Exmoor, mares live in groups of about 15 females with one stallion (depending on the maturity of the male and the number of stallions around) (Baker 1993). They maintain separate home ranges, although there is some overlap.

5.11 On Dartmoor, where the system is similar, home ranges appear to be maintained by stallions, with territorial displays, fighting and herding behaviour seen by stallions in areas where overlaps occurred (Freshney pers. comm., based on research for BSc dissertation). Territories may be less strongly maintained in the winter, when ponies may become more tolerant and move towards the edge of the moor.

5.12 There is concern that the removal of stallions from Dartmoor may result in the breakdown of these home ranges with consequences for traditional grazing patterns. Freshney suggests that the maintenance of several harems results in at least one herd being pushed into the moor. However, a recent behavioural study (Petrie-Ritchie 2015) suggests that dominant mares tend to dictate where the ponies spend their time, although it was suggested that bonds between individuals might weaken if stallions are removed.

In the absence of stallions in some areas, ponies tend to disperse into smaller groups with overlapping ranges.

5.13 In the New Forest, where stallions are removed for part of the year, ponies tend to be widely dispersed in small groups. Tyler (1972) found that these groups used identifiable home ranges of 82-102 ha that often overlapped on favoured habitats, although groups used the overlapping areas at different times. Groups usually comprised one mare with one or more offspring, sometimes two mares and occasionally up to six. These were generally, but not exclusively, family groups (Tyler 1972).

5.14 When stallions are reintroduced to the New Forest during the breeding season, the small groups coalesce into harems maintained by a stallion. Gill (1987) found that any stallions remaining outside of the breeding season tended to maintain an association with a single small mare group, rather than the whole harem. Tyler found

no evidence of territorial behaviour, but Pollock (1980) recorded strongly territorial behaviour by stallions, with harems remaining in discrete areas.

5.15 On other sites where the herding behaviour of ponies has been studied, it was found to vary between groups. Seven Exmoor ponies (mares and geldings) grazing around 380 ha on Hartland Moor in Dorset generally remained in one herd, while New Forest mares on the same site tended to disperse into smaller groups (Lake 2002). No stallions were present. Although both herds had been present on the site for some years, their background and make-up were different, and the difference cannot necessarily be attributed to breed.

Ponies can travel several km in 24 hours. In gorse brake and dry heath, ponies maintain clearly defined paths. In grassland they tend to move in a less focussed manner.

5.16 Tyler (1972) described ponies in the New Forest as 'drifting' during the day, grazing as they went. Pollock (1980) found that heavily used areas were affected by the frequency, rather than duration of pony visits, suggesting that ponies moved through, rather than staying in one place for long. At nightfall, ponies headed more purposefully in single file towards valleys and woodlands, traveling up to about a mile. This was noted in the summer months in Dorset, where ponies galloped for about one km at sunset (pers. obs.). In general, Exmoor ponies were noted to travel on clearly defined paths through dry heath and gorse brake, but to meander across grasslands (Lake 2002).

5.17 Wild Przewalski horses roam several km per day (King 2002). On the Dorset heaths, Exmoor ponies at Hartland Moor were recorded travelling up to 10 km a day (mean 7 km); New Forest ponies travelled up to 8 km (mean 5.6 km). On a smaller nearby site, New Forest ponies only travelled around 2 km per day.

Pony ranges change in winter and may contract.

5.18 A contraction in the range of ponies was recorded in winter in the New Forest and Dorset (Tyler 1972; Lake 2002), with a corresponding reduction in the number of habitats used and the distance travelled. Tyler suggests that in the New Forest, summer range expansion was due to the use of 'shades' (see para 5.23 below). However, Pollock (1980) found no difference in the number of 100m grid squares entered by ponies in winter and summer.

5.19 On Dartmoor, Freshney (2001) observed little difference in the range occupied by ponies in winter compared to summer, although she suggests that different tors were favoured in winter and summer in the year the work was undertaken. Oates (1994) suggests that Dartmoor ponies may move into valley bottoms in the winter to exploit any grass growth due to slightly warmer conditions. Home ranges of wild Przewalski horses were shown to change with season and year (King 2002). Lake (2002) suggested that ponies did not travel far after dark, which might be one explanation for seasonal differences in distance travelled. Decreased energy expenditure could be another - Morel (2006) found that, during winter, Welsh Mountain ponies demonstrated behaviours indicative of a cost benefit analysis of expending energy in the pursuit of poor quality forage.

Free-ranging cattle can exhibit strong herding behaviour, and are more likely to range as a herd than ponies or sheep. In some situations, they may avoid habitat patches that are too small to accommodate the whole herd.

Cattle

5.20 Cattle show strong herding behaviour (Arnold & Dudzinski 1978). In the New Forest, cattle form groups of at least 10 individuals, and are therefore less widely dispersed than ponies. Herd cohesion is high, with individuals tending to engage in the same behaviour as the rest of the herd. In the New Forest, this degree of social cohesion has implications for habitat selection. Pratt *et al.* (1986) noted that cattle avoided grasslands that were too small to accommodate the whole herd, such as streamside lawns and roadsides. In the New Forest, cattle ranges are influenced by the provision of supplementary feed in the winter (Ekins 1989).

5.21 Herding behaviour may however be site or group specific. For example, in Dorset, a herd tended to stay together at one heathland site, while at a second the herd fragmented into separated into small groups in about August (Lake 2002). This was possibly because the larger grassland areas had been depleted, and animals were forced to use small parcels of grassland, roadsides, and linear mires. However, individuals within a herd were also noted to graze in different adjacent habitats when habitat patch size was small.

Cattle can create paths through heather on 'route marches' between favoured areas.

5.22 In Scottish uplands cattle are considered more likely to move around their range as a herd than sheep, but will range as widely as sheep if left out for enough of the year to become familiar with range (Armstrong 1996).

5.23 Pratt *et al.* (1986) found that cattle moving from foraging to resting habitats often undertook a purposeful 'route marches'. On still clear nights this was often just onto nearby heathland, but in rain or conditions of poor visibility (and in winter) they sought shelter in woodland.

Cattle may have smaller home ranges than ponies

5.24 Cattle observed on two heathland sites in Dorset travelled shorter distances than ponies, covering about one km in winter, and up to six km in summer (Lake 2002).

Sheep

Sheep in the uplands are typically hefted to a particular area within the overall home range of the flock. As with ponies, these areas may overlap.

5.25 Sheep in the uplands typically flock together in groups of about 100 and stay largely within a home range that may be bounded by topographical features such as streams and ridges. Within flocks there are subgroups made up of related females, which occupy a heft within the overall home range. These overlap with other hefts, so the flock spreads out over most of the larger home range (Armstrong 1996). Hefting, which may result in sheep being spread around on common grazing areas, is influenced by the location of the farm and access point, not just vegetation (Martin *et al.* 2013).

Sheltering and 'shading'

The availability of shelter is likely to influence site use by ponies, which may move significant distances to reach shelter at night. This is likely to be site specific and may vary between breeds.

5.26 In some areas the location of shelter influences habitat use by ponies. In the New Forest, ponies generally moved into woodlands or valleys at night (Tyler, 1972; Pratt *et al.* 1986). In winter, this was more pronounced and ponies also made greater use of gorse brake (Putman *et al.* 1987). The contraction of range seen in ponies in winter may have been due to a preference for staying in the vicinity of shelter. On the Dorset heaths, livestock resting areas for cattle and ponies were found to be closer to shelter than random points (Lake 2002). On Dartmoor, Freshney (2001) observed ponies sheltering from prolonged or heavy rain or high winds behind stone walls, in gorse, in tall bracken and in hollows and this behaviour may therefore have influenced pony dispersal in such weather.

5.27 Similarly, sheep are known to use wall and woodland to shelter from adverse conditions (e.g. Armstrong 1998). In the New Forest, cattle used woodland for shelter, but rarely used gorse brake (but note that most cattle are removed for the winter). On one Dorset heath, cattle were observed using tall, degenerate dry heath for shelter in cold conditions in late autumn (Lake 2002).

5.28 A related behaviour is known as 'shading'. In summer, ponies can spend several hours standing resting, often in large groups (e.g. Pratt *et al.* 1986). This often occurs on higher ground, presumably where there is more of a breeze, as is thought to be a response to hot weather and the presence of flies (e.g. Tyler, 1972; King 2002). Freshney (2001) suggested that ponies may generally prefer higher ground, although data were not available to support this. No references were found of other livestock types undertaking this activity, although Steward & Eno (1998) noted that sheep may move uphill in the summer to avoid flies. Cattle also move uphill on summer evenings in the Lake District and in the Cevennes in France, possibly to avoid biting insects in the valleys (Underhill-Day, pers. obs.).

In warm weather, ponies often gather together in groups on high ground, forming 'shades'.

Availability of water and supplementary feed.

5.29 The location of supplementary feed (e.g. hay or mineral licks) may influence habitat selection and range in ponies. For example, ponies given hay on a site in Dorset were found to remain close to the feeding area and to reduce their use of other habitats and their range accordingly (Lake 2002). However, on Exmoor, Baker (1993) found that Exmoor ponies tended to ignore supplementary feed provided in harsh weather.

Cattle and sheep tend to be strongly influenced by the location of supplementary feed. In ponies, the response to supplementary feed may vary between pony types or sites.

5.30 Sheep are known to congregate around winter feeding areas (e.g. Armstrong, 1998) and may remain there for several hours before and after feeding. Similarly, Ekins (1989) found that cattle remaining in the New Forest throughout winter spent most of their time around the area where feed was provided.

The location of water is less likely to influence habitat use in ponies than cattle. However, it will depend on the characteristic of individual sites.

5.31 The availability of water may also influence how livestock use a site. Armstrong (1998) states that cattle may congregate around a water source, unlike sheep. Oates (1994) suggests that ponies require less water than cattle, but that the location of water may nonetheless influence grazing patterns in extensive systems. On Dartmoor, Freshney (2001) found that ponies usually had easy access to water in the form of frequently occurring small streams, and that the location of water did not seem to influence habitat use. In Dorset, it was noted that livestock made forays to water sources, as water was not available in the preferred areas of acid grassland (Lake 2002).

Latrines and dunging

Ponies create latrines when enclosed in paddocks or when grazing in small, defined habitat patches. In extensive areas latrines are not formed.

5.32 In enclosed pastures, ponies create latrines by dunging in specific areas that are then avoided while grazing (Odberg & Francis-Smith 1976) . However, in extensive systems, ponies are not thought to do so (e.g. Lamoot *et al.* 2004). On Dartmoor, Freshney observed that Dartmoor ponies on enclosed Purple Moor-grass pastures used latrines, but did not do so on the commons.

5.33 Tyler (1972) found no evidence of use of latrines by New Forest ponies, but note that when resting in shade, ponies moved a few steps away to defecate and then returned. However, Edwards and Hollis (1982) identified distinct latrines on areas of reseeded grassland in the New Forest. They observed that ponies avoided grazing in latrine areas, resulting in a longer sward in these patches

5.34 Lamoot (2004) found that Konik horses, Haflinger horses and Shetland ponies tended to defecate where they were grazing, rather than move into a different vegetation type. However, Lake (2002) found significant differences between habitats for Exmoor ponies. Dunging in areas of grass/heather mosaic and on dry heath was significantly higher than expected, while dunging on acid grassland was lower than expected. No such difference was found for New Forest ponies on the same site.

There is a little evidence to suggest that cattle may dung more in areas where they congregate such as resting places, but not that they create latrines.

5.35 The latrines identified by Edwards and Hollis (1982) were thought to be used by ponies, cattle and deer. However, it was suggested that this was because cattle and deer were unable to graze the very short sward created in the non-latrine areas by ponies, and so these animals grazed and defecated in pony latrine areas, but not non-latrine areas.

5.36 It is thought that cattle generally drop their dung randomly rather than use latrines, although there may be concentrations around gates or feeding areas or where cattle rest at night (Marsh and Campling 1970 in Edwards and Hollis 1982). In Dorset, Lake (2002) found that dunging by cattle was greatest in the habitats where most time was spent, but was disproportionately high in woodland and scrub at one site. Lake (2002) observed that cattle, and to a lesser extent ponies, tended to defecate on standing up after resting and before moving off or starting to graze.

Rolling, resting and trampling

Unlike cattle and sheep, ponies roll. There is no evidence to suggest that ponies use specific habitats for rolling, although bracken, sandy patches and wet grass are known to be used.

5.37 Ponies roll, a behaviour which results in vegetation being crushed. Freshney (2001) noted that this occurred in bracken, where the effect was quite noticeable, opening up the bracken canopy. Tyler (1972) suggests that in the New Forest, specific sites are not used for rolling, but that ponies often rolled in sand and wet grass (also saw dust) as a form of grooming. This was socially facilitated and often occurred after a period of resting or lying down. Cattle and sheep do not roll.

5.38 All livestock spend a proportion of their time resting. Ponies spend less time resting than ruminants such as cattle and sheet, and rest standing up in addition to lying down. Lake (2002) found that the amount of time ponies spent resting was greater than that spent foraging when in dry heath and (for Exmoor but not New Forest ponies), in woodland and on tracks. Casual observation suggested that ponies tended to return to favoured resting places each night.

5.39 The same work showed that cattle spent significantly more time resting than foraging when on dry heath, and this difference was greater than for ponies. They also spent more time resting in woodland. The proportion of time spent resting on acid grassland was quite high, and was more than the proportion spend grazing at one site (unlike ponies).

5.40 It is known that sheep prefer to lie on paths or grassy patches (Martin *et al.* 2013).

Ponies may spend more time than cattle in habitats where trampling will have a greater impact.

5.41 Trampling is a consequence of animals moving, and so is not likely to be a determinant of habitat selection, but it is included here for completeness. Work on the Dorset heaths showed that Exmoor ponies spent more time moving than other behaviours on dry heath and spent a high proportion of their time on tracks moving. New Forest ponies also spent a high proportion of their time moving on dry heath. This contrasted with cattle, which spent a low proportion of their time on dry heath moving. However, they also spent more time moving on tracks.

5.42 Ponies may penetrate further into wet habitats or bracken than cattle (e.g. Pratt *et al.* 1986) or sheep; these are habitats in which trampling will have more impact.

6. Diet

Context

6.1 The dietary preferences of livestock generally determine which habitats are preferred in heterogeneous sites, as discussed above. They also mean that plant species may be differentially affected by pony foraging within a given habitat.

6.2 Plant species differ in their nutrient and secondary compound contents and younger foliage is often more nutritious than older foliage. For example, species such as Bracken *Pteridium aquilinum* are considered to be relatively unpalatable due to a variety of toxic constituents, while Mat-grass is fibrous and contains high levels of silica. In contrast, other species such as bent-grasses *Agrostis* spp. are very attractive to herbivores. However, plant quantity may be more important than quality. For example, Arnold (1987) found that sheep concentrated their grazing on patches where the yield was highest, and effects of plant species palatability were only noticeable once this had been taken into account. Similarly, Hartley *et al.* (1997) found that deer selected the trees they browsed on the basis of size.

Ponies

Ponies are more adaptable than cattle and can alter their diet to maximise their intake of forage of high nutritional quality.

6.3 Ponies are considered to be adaptable in their dietary choices. For example, Putman *et al.* (1987) found that pony diet correlated with productivity and digestible nitrogen content of foraged plants, suggesting that ponies can adjust their diet to ensure maximum intake of digestible dry matter of high nutritional quality in any season. A lack of this flexibility in cattle was suggested to be related to ruminant physiology and social constraints.

Ponies strongly prefer grasses but are adaptable and able to eat a wide range of other plants.

6.4 Despite this flexibility, ponies mainly eat grass. At its summer peak, pony diet in the New Forest was 92% grasses (Putman *et al.* 1987), although this dropped to about 40-60% in winter. In Exmoor ponies, grasses formed 58% of the diet overall. Lake (2002) found that only grasses were eaten in a greater amount than would be expected by availability. On Dartmoor, Freshney (2001) found that ponies preferred both coarse and fine grasses. However, they were able to switch to Bramble, Heather, gorse and even willow *Salix* sp., birch *Betula* sp. and Blackthorn *Prunus spinosa*. She also observed ponies eating ferns, Marsh Thistle *Cirsium palustre,* rushes *Juncus* spp., Bilberry *Vaccinium myrtilis*, Bogbean *Menyanthes trifoliata*, Deergrass *Trichophorum cespitosum* and Common Cotton-grass *Eriophorum angustifolium*.

Ponies can eat substantial amounts of gorse.

6.5 At times, gorse can form a substantial part of the diet of ponies. Harris (in Petrie-Ritchie 2015) observed that ponies on Dartmoor switched to eating almost 100% gorse when browsing in swaled areas where the gorse was charred. Ponies appear to prefer Western Gorse (*Ulex gallii*), which they take from within Western gorse damp heath (H4 within the National Vegetation Classification) (Freshney, pers. comm.). Worth (in Ward et al. 1972) noted that ponies ate young gorse and trampled older gorse with their hooves before eating it. In Spain, horses are used to control gorse in pine forests to reduce fire risk (Rigueiro-Rodríguez et al. 2012). Ferreira et al. (2013) noted that horses seemed to be able to deal with the spiny shoots of gorse, and consumed it in the autumn. Ponies may browse other woody plants a little. For example, Pratt et al. (1986) found that ponies ate Holly, and Dartmoor ponies grazing in Yarner Wood on the edge of Dartmoor have been observed to strip holly bark (Freshney, pers. comm.). In general, equines (also cattle and sheep) browse more when other forage is limited (e.g. Ferreira *et al.* 2013).

Ponies eat relatively little Heather.

6.6 Ponies are thought to eat relatively little Heather. Freshney (2001) made no observations of Heather foraging on two Dartmoor commons in summer, and one 1% of observations in winter. In Cantabria, Spain, Celaya *et al.* (2011) found that mares selected grasses and rejected heather species more than did cattle on heathland, particulary in summer. Tolhurst & Oates (2001) suggest that Dartmoor ponies may browse heather tops "if pushed". In Dorset, Heather accounted for only 8% of bites when ponies were foraging on dry heath that was 92% Heather. However, on Exmoor, Baker (1993) found that Heather contributed about 10% of the diet overall, rising slightly to 14% in winter.

Ponies may consume Bracken, particularly in late summer.

6.7 Ponies are considered to Bracken (e.g. Oates 1994) particulary in August and September when toxicity levels decrease. On Dartmoor, Freshney (2001) observed that Bracken accounted for 22% and 5% of foraging observations respectively at two different sites when Dartmoor ponies were in Bracken-dominated vegetation (grass made up the remainder) (but note that this was based on just two visits). In Dorset, Exmoor ponies positively selected Bracken when foraging in dry heath, although New Forest ponies on the same site did not (Lake 2002). In the New Forest, Pratt *et al.* (1986) found that ponies made more use of Bracken than cattle (also cotton-grasses, sedges and mosses).

6.8 Ponies are renowned for not selecting flower heads of plants (e.g. Oates 1994), unlike sheep. No data relating to this were found. There is anecdotal information to suggest that on Dartmoor, ponies do not eat Devil's-bit Scabious *Succisa pratensis*, the food plants of Marsh Fritillary, whereas cattle may graze it sufficiently to limit it to a rosette form (J. Plackett, pers. comm.).

Pony diet is seasonal, with gorse providing nearly a half of winter forage.

6.9 Diet is seasonal. For example, in the New Forest, Putman *et al.* 1987 showed a marked switch to a summer diet in April/May and to a winter diet between October and December. On Dartmoor, the amount of grasses taken dropped from up to 98% of observations in summer to between 2% and 45% in the winter (Freshney 2001). On Exmoor, grasses provided 31% of the diet of Exmoor ponies in winter, rising to 76% in summer (Baker 1993). In winter the difference is often made up of gorse. On Exmoor, gorse contributed up to 40% of the diet in winter but was only 9% in summer (Gates 1979); on Dartmoor gorse contributed 45% to the winter diet.

Ponies' use of Purple Moor-grass peaks in spring and early summer.

6.10 Use of Purple Moor-grass is also highly seasonal. In the New Forest, this grass made up 20% of the diet from May, being replaced by Bristle Bent in August, and gorse and Holly in winter (Putman *et al.* 1987). On Dartmoor, Purple Moor-grass was a primary forage species between June and August, becoming secondary in September and October (note that it was not possible to continue the study from March to June, the period when Purple Moor-grass growth and therefore consumption is likely to be highest). Similarly, Lake (2002) found that Purple Moor-grass was positively selected when ponies were in valley mire and wet heath during the summer. However, on Exmoor, Baker (1993) found very little evidence of Purple Moor-grass in the diet of Exmoor ponies.

Cattle

The diet of cattle is also strongly grass-based. Unlike ponies this shows little seasonal variation.

6.11 The diet of cattle is also very strongly grass-based. In the New Forest, grasses made up around 78% of the diet averaged over the year (Putman 1986), and this showed less seasonal variation than ponies. Unlike ponies, cattle ate little Purple Moor-grass in the New Forest. Data from Dorset suggest that cattle preferentially select Purple Moor-grass when grazing valley mire, although they use this habitat infrequently (Lake 2002).

Cattle may eat more Heather than ponies.

6.12 Cattle have been observed to spend more time on heathland than ponies, and may make more use of Heather (e.g. Putnam *et al.* 1987). On the Dorset heaths, cattle positively selected Heather when foraging on regenerating dry heath at one site, although on another they positively selected grasses. They avoided Heather on mature dry heath. Ferreira *et al.* (2013) found that cattle and sheep tended to select heather in moderate amounts in a heath/grassland complex in Spain.

Unlike ponies, cattle eat little gorse.

6.13 Cattle are considered to eat little gorse. In the New Forest, no gorse fragments were found in cattle dung (Putman 1986). Ferreira *et al.* (2013) found that cattle (and sheep) tended to avoided gorse across the grazing season. However, in Dorset, at one site studied, cattle positively selected Dwarf gorse *Ulex minor* and pine *Pinus* sp. seedlings when foraging on dry heath in autumn.

6.14 Putman *et al.* (1987) found seasonality to be much less pronounced in cattle than in ponies. The species composition of the dung remained constant at around 70-80% grass (including hay in

winter), with the rest being mostly made up of Heather and *Erica* sp.

Sheep

6.15 Diet selection in sheep (and deer) has been shown to remain relatively constant, with both maintaining a preference for grass over heather even when the availability of grass decreases (Hester *et al.* 1999). On moorland sites, sheep have been shown to avoid Mat-grass, Purple Moor-grass and rushes *Juncus* spp. in favour of other grasses and also Heather (Welch 1986; Hartley 1997; Alonso, Hartley & Thurlow 2001). Sheep are also able to detect small variations in plant quality within a species, for example preferentially grazing the new shoots on Mat-grass tussocks, which are higher in nitrogen and less tough than older shoots.

6.16 Sheep are considered to graze more selectively than cattle (Martin et al. 2013). For example, when high quality forage becomes limiting, cattle tend to maintain their level of intake at the expense of digestibility, while sheep are more selective and maintain digestibility at the expense of rate of intake (Armstrong & Hodgson 1986). Sheep show greater variability in diet composition, and are more selective. They are less likely to eat dead vegetation than cattle (Grant *et al.* 1985).

6.17 In the Scottish uplands, cattle were found to eat more cotton-grass on blanket bog than sheep (Grant *et al.* 1985). Cattle were also more likely to eat rushes than sheep, and less likely to eat Heather, although cattle removed more woody material when they did eat heather. Cattle are more likely to eat Mat-grass than sheep and in summer may graze Purple Moor-grass more readily (Martin *et al.* 2013) The difference in cattle and sheep diet increases after June (Grant *et al.* 1985).

6.18 In comparing the diets and grazing time of ponies, cattle and sheep on heath and adjacent grassland, Ferreira (2013) found the highest level of similarity to be between cattle and sheep, followed by cattle and ponies, with less similarity between ponies and sheep.

7. Summary of the likely impacts of pony grazing on moorland

Context

7.1 There is very little published data on the impacts of pony grazing on heathlands. Potential impacts can be extrapolated from the behavioural data and anecdotal observations available, together with impacts from other habitats. However, whether impacts are beneficial in terms of nature conservation will depend on intensity; for example a degree of trampling can open up niches for less competitive plants and for animals, while high intensity trampling will lead to wider loss of vegetation and poaching. The intensity of impacts will depend on stocking rates and site characteristics (such as pinch points and the distribution of favoured habitat patches).

Ponies may have more impact than other livestock types in valley mire, wet heath and gorse brake.

Implications of how sites are used

7.2 Ponies are likely to make more use of wet heath and valley mire than both cattle and sheep in the summer and more use of gorse brake than cattle, particularly in the winter. On extensive heterogeneous sites, ponies may range more widely than cattle (this may be partly due to husbandry). They are likely to make use of more habitat types and more habitat patches, including smaller ones.

7.3 There is no published quantitative evidence available about the actual impacts of these preferences on plants and animals. However, it is likely that ponies will have more of an impact in bracken-dominated vegetation, wet heath and valley mire than the same number of livestock units[5] of cattle or sheep. This will be through vegetation removal, trampling, dunging and possibly the break-up of litter. For example, cattle trampling and dunging can provide feeding sites for Snipe *Gallinago gallinago* and it seems probable that pony trampling and dunging will have a similar effect (Cadbury 1992).

The impacts of pony grazing and trampling may be more dispersed across the landscape than that of cattle. They may impact on a wider range of habitat types and patch sizes.

7.4 Ponies may be more dispersed over the landscape than cattle, although this may depend in part whether stallions are present.

[5] Livestock units are based on feed requirements of different livestock, in terms of cow equivalents. Ponies are considered to be equivalent to up to two LUs.

They may be more likely to use small habitat patches, and are likely to travel further than cattle. Habitat selection in ponies is less likely to be influenced by the location of water than in cattle. Depending on the breed and background of the ponies, they may also be less influenced by the location of supplementary feed.

Out-wintering means ponies may have more of an impact in woodland and gorse brake, and, in spring, on Purple Moor-grass swards.

7.5 Differences in husbandry, specifically out-wintering and lack of regular supplementary feeding, mean that ponies may have more of an effect in woodland and gorse brake than cattle, but this may be site specific. Ponies may also have more of an impact of Purple Moor-grass through being on site when the first flush of growth occurs.

Implications of foraging behaviour

Ponies may eat a wider range of plants than cattle and sheep, and may be less likely to select flower heads than sheep.

7.6 Evidence from faecal examination and direct observation suggests that ponies may eat more Purple Moor-grass, Bracken and gorse than cattle and sheep. Ponies are also likely to eat a greater range of species. There is anecdotal evidence to suggest that they are less likely to select flower heads than sheep.

7.7 There is little evidence to show the impacts of these dietary preferences on extensive heathland sites. Freshney (pers. comm.) suggests that a decline in pony grazing on Dartmoor maybe linked to an increase in Purple Moor-grass. Oates (1994) suggests that ponies may have more of an impact on bracken than other livestock by nibbling along the edges of stands and opening up paths and glades, and ponies may break up bracken litter (Tolhurst & Oates 2001). Lamoot *et al.* (2004) found that horse grazing alone and mixed horse and cattle grazing created more structural variety than cattle grazing alone in sand dune systems.

Ponies may eat more Purple Moor-grass and Bracken than cattle and sheep.

Ponies, like sheep, are likely to create a shorter sward than cattle.

7.8 Pony physiology means ponies are likely to create a shorter grassland sward than cattle, but not necessarily sheep. Where latrines are created, they will create a more structurally diverse swards. Oates suggests there is some evidence to suggest ponies create a more diverse sward, of benefit to invertebrates, than other livestock types

Given ponies' greater preference for Purple Moor-grass, they may be more effective than cattle in creating diversity in wet heath and valley mire, but there is as yet little evidence for this.

7.9 Cattle grazing has been shown to decrease the sward height of Purple Moor-grass and increase plant species diversity (e.g. Lake 2002; Groome & Shaw, 2015). Welsh Mountain ponies brought about a shift from species-poor tall grassland to a more species-rich community in dry dunes and an increase in positive indicator species in wet dune habitats (Plassmann, Jones & Edwards-Jones 2010). However, no studies on the impacts of ponies on species diversity on heathlands have been found.

7.10 Impacts may be related to changes in vegetation structure as well as composition. For example, counts of Southern Damselfly *Coenagrion mercuriale* increased in a mire on Dartmoor already grazed by cattle when pony grazing increased (Baldock 2009). Dartmoor ponies ate rushes and tough grasses, opening up runnels in a wet grassland suitable for Southern Damselfly. On wet heath sites in the Cragou, Brittany, Curlew *Numenius arquata* numbers were highest where Purple Moor-grass had first been cut then grazed by Dartmoor ponies (Francois de Beaulieu pers. comm. in Freshney 2001) (it is not clear what the other treatments were). Anecdotal evidence suggests that ponies produce a more varied height and structure in grassland swards (important for insects as it creates sheltered niches and a warm micro-climate at ground level) (J. Plackett, pers. comm.) but this will depend on grazing pressure.

Ponies may have more of an impact on gorse brake than cattle.

7.11 Ponies may have more of an impact than cattle in gorse brake, nibbling shoots and potentially breaking up dense stands by creating paths. However, on a dune system, cattle were considered more likely to impact on scrub by opening up closed scrub and by direct consumption.

Pony dunging can introduce nutrients and seeds of grassland plants onto heathland (as can cattle and sheep dunging).

Implications of dunging

7.12 The main impacts of dunging on heterogeneous heathland sites are the transfer of nutrients onto nutrient-poor heathlands (e.g. if livestock grazing more fertile swards tend to use heathland disproportionately for dunging), the introduction of plant propagules (potentially leading to an increase in grasses), and an increase in the abundance of invertebrates dependent on dung.

7.13 Pony dunging may lead to localised nutrient enrichment and the introduction of grasses into heather dominated communities; there is inadequate evidence to evaluate whether this is likely to be lesser or greater than the dunging impact of cattle. Welch (1984) suggests that about 25% of the Heather decline attributed to cattle in upland agricultural systems in Scotland was due to the adverse effects of dunging.

On enclosed sites, ponies may create latrines, resulting in potentially beneficial structural diversity in the sward. This is unlikely in most extensive sites.

7.14 In enclosed areas or where strongly preferred habitat patches are small and clearly defined, ponies may create latrines. This will lead to a diverse sward structure, as ponies avoid latrines for grazing. This is not seen with other livestock types on their own.

Implications of trampling, rolling and resting

Pony trampling may have less of an effect than cattle trampling in a given habitat. However, ponies make more use of habitats where trampling will have a greater effect.

7.15 There is little quantitative work specifically assessing the impact of livestock trampling on heathland. Lake (2002) found that artificial trampling resulted in the return of some key heathland species at sites where they were considered extinct, as trampling enabled species to regenerate from the buried seedbank on site that were ungrazed or only lightly grazed. However, no differentiation was made in this work between livestock type (although the trampling was intended to replicate cattle trampling).

7.16 The fact that ponies spend less time resting than ruminants, and also spend a proportion of their resting time standing up, suggests that ponies may have less impact on vegetation likely to be susceptible, such as degenerate dry heath. No evidence for this was found, although there is evidence to suggest that cattle spend more time on dry heath resting, and so could have a greater impact through crushing vegetation on this habitat than ponies. Ponies may disperse more widely than cattle, which are more likely move as a herd, and may therefore have less of a poaching impact.

Ponies can impact on Bracken stands. Their greater preference for Bracken suggests they may do this more effectively than cattle but again there is no evidence available.

7.17 Harris (in Freshney 2001) suggests that pony trampling in bracken creates conditions suitable for fritillary butterflies, but there are no data available on actual impacts to fritillaries.

Interactions with other livestock types

Mixed grazing may have more benefits than single species grazing.

7.18 There is some evidence to suggest that mixed grazing using more than one livestock type will benefit biodiversity (Martin *et al.* 2013). For example, a long-term project at Glen Finglas in Scotland showed

that grazing both cattle and sheep was preferable to grazing just sheep, because of their different feeding habitats (Evans *et al.* 2015). In a study of mixed grazing on the restoration of degraded upland wet heath, cattle and sheep grazing resulted in a decline in the biomass of Purple Moor-grass, unlike sheep-only grazing (Critchley *et al.* 2008).

Ponies may directly and indirectly influence habitat selection by other species.

7.19 Grazing with ponies in addition to cattle and sheep may therefore have a different impact than grazing with just one or two of these livestock types. For example, on a coastal wet grassland site in France, Loucougaray (2004) found that mixed horse and cattle grazing produced the most species-rich and structurally diverse swards.

Ponies may facilitate grazing by other species, but there is little evidence to show this.

7.20 The different effects of combined grazing may be due different livestock species using different habitats or forage. It may also be due to one livestock type directly or indirectly influencing the patterns of habitat use of another.

7.21 In the New Forest, ponies were observed to be dominant over cattle (Ekins, 1989). Anecdotal information suggests this is also the case elsewhere. It was observed on the Dorset heaths, and is noted in exchanges on the Nibblers electronic conservation grazing forum, with reports of ponies both chasing away cattle but allowing sheep to feed with them, and ponies chasing away sheep. While it is apparent that ponies may be dominant over other livestock types, there is no data available to suggest how this may affect grazing patterns of other livestock. It could result in the displaced animals grazing on habitat patches or types otherwise less likely to be grazed, or merely using the same habitat patches but at different times. Arnold (1984) found that although there was overlap in the distribution of sheep, cattle and horses in a paddock, there was temporal separation.

7.22 Livestock may also indirectly influence habitat use by other species. Pratt *et al.* (1986) observed spatial separation of use in grassland areas in the New Forest, as ponies avoided latrines but cropped the remaining area very short. Cattle were displaced from these areas as the swards was too short, and grazed in the pony latrine areas (meaning the latrines also contained a higher proportion of cattle dung). On Rhum, ponies and deer were found to displace cattle from more fertile swards onto areas of Purple Moor-grass and Black Bog-rush when the preferred sward became too closely grazed for the cattle (Gordon, 1989). However, manipulative experiments carried out by Hester *et al.* (1999) found that overall patterns of foraging behaviour by sheep and deer were little affected by the presence of absence of the other species.

Ponies are likely to provide a valuable addition to cattle and sheep grazing in terms of wildlife benefits. However there is as yet little direct evidence for this.

7.23 Livestock may also facilitate grazing by other species. For example, Freshney (2001) conjectures that ponies, by breaking up burnt gorse, may facilitate sheep grazing on the grass underneath.

7.24 Overall, there is evidence to suggest that ponies provide a valuable addition to cattle and sheep grazing in the creation of varied and species-rich vegetation. There are likely to be favourable knock-on effects for invertebrates and birds.

8. Knowledge gaps

Knowledge gaps include:

- **Actual impacts of pony grazing on Dartmoor, including on invertebrates and breeding and wintering birds**
- **Site specific use of habitats and features**
- **Seasonal variation**
- **Dispersal compared to cattle**
- **The interaction between pony, cattle and sheep grazing**

8.1 Much is known about pony behaviour on extensive lowland heathland sites (e.g. the New Forest, the Dorset heaths and other sites) and a little from the uplands (e.g. Exmoor and Dartmoor). This includes habitat use, dietary preferences, seasonal variation and how other behaviours are likely to affect site use. There are also useful comparisons with cattle, showing where there are similarities and differences in likely habitat use and diet due to physiological and husbandry differences.

8.2 However, there is evidence that some aspects of habitat use and diet are likely to be site-specific, depending on characteristics of the site such as the distribution of habitats, the size of habitat patches and the location of shelter or positions suitable for 'shading'. The existing work on Dartmoor is very useful, but is limited to two commons and two enclosed Purple Moor-grass and rush pasture sites over about nine months. More information on how ponies use habitats on Dartmoor would be useful in the context of evaluating the role of ponies in the ecology of Dartmoor.

8.3 A more detailed understanding of habitat selection by ponies on Dartmoor would include their use of dwarf-shrub dominated wet and dry heath, grass-dominated moorland, Purple Moor-grass and rush pasture, gorse brake, bracken-dominated habitats, and mires (including blanket bog and valley mire). In particulary little is known about pony preferences for blanket bog. Any work needs to address seasonal variation – the work by Freshney was unfortunately cut short due to Foot and Mouth Disease, and she was not able to look at habitat use in spring. Spring habitat use is of particular interest because of the potentially higher use ponies make of Purple Moor-grass than other livestock.

8.4 It would also be useful to obtain data on the dispersal of ponies compared to cattle and sheep on Dartmoor, as ponies herds may range over a greater area and disperse more widely.

8.5 There is little evidence of the actual ecological impact of pony grazing, particularly in comparison with that of cattle and sheep. Again, this would ideally address dwarf-shrub dominated wet and dry heath, grass-dominated moorland, Purple Moor-grass and rush

pasture, gorse brake and mires (included blanket bog and valley mire).

8.6 There is very little information on the effects of pony grazing, trampling and dunging on invertebrate populations. While there is some information on the impacts of ponies on bracken in relation to fritillary butterflies, any link with fritillary populations has not been made.

8.7 There seems to be no information on the effects of pony grazing and trampling on populations of breeding or wintering birds or on small mammal populations. Cattle grazing may provide suitable conditions for waders on moorland by creating a varied sward (e.g. Fuller *et al.* 2002). However, declines in waders have been attributed to intensive sheep grazing (Sim *et al.* 2005) and on grassland, there is evidence that inappropriate grazing may damage populations through nest trampling (e.g. Sabatier, Doyen & Tichit 2010; Beintema & Muskens 1987). Pony grazing can also create a varied sward and, on moorland, is unlikely to be at sufficiently high intensity to lead to significant nest trampling. While it seems probable that the activities of ponies in wetter moorland habitats may facilitate suitable vegetation structures for some nesting wetland birds and create feeding opportunities, this has not been studied.

8.8 Little is known about interaction between pony, cattle and sheep grazing. There is evidence to suggest that mixed grazing may have the most benefit for wildlife, but there is as yet little evidence to show this on Dartmoor.

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Appendix I. Publications reviewed.

Authors	Publication type	Description
Armstrong and Hodgson, 1986	Journal paper	Indoors experiment with cut forage plus observations and fistulation outdoors on 5 community types
Armstrong, H. in Stewards & Eno 1998	Report	Appendix 6 of Stewart and Eno 1998 (livestock behaviour) based on published work by MLURI but not clearly referenced however useful summary of literature from Scottish uplands
Arnold 1984	Journal paper	Distribution of merino sheep, north devon cattle and thoroughbreds in a paddock
Baker, 1993	Book	Results of PhD on Exmoor ponies. Mainly observational but diet based on faecal analysis.
Baldock, 2009	Report	Article describing southern damselfly monitoring results. Presents monitoring data and anecdotal description of impact of ponies on vegetation
Baldock, 2010	Report	Distribution of ponies in forestry restoration. Unpublished data. Includes some statistical analysis (no info on size of dataset etc.)
Critchley et al. 2008	Journal paper	effects of cattle and sheep grazing vs sheep only grazing on degraded upland wet heath
Celaya et al. 2011	Journal paper	20 cows (seven lactating their calves and thirteen dry) and 20 mares (eight lactating their foals and twelve dry) were managed during 3 years on a heathland area from June to September and October
Ferreira 2013	Journal paper	Foraging behaviour (grazing time, diet selection) and overlap in vegetation use between five beef cows, five mares, 32 ewes and 32 goats suckling their offspring born in late winter–early spring, was compared across the grazing season (May–December). Animals were managed in mixed grazing on heather–gorse vegetation communities with an adjacent area (24%) of ryegrass–clover improved pasture. Asturias, Spain
Fleurance et al. 2001	Journal paper	Mares grazing natural wet grassland in Marais Poitevin (France)

Authors	Publication type	Description
Freshney 2001	Report	Observation on 4 sites, two open Commons and two enclosed Rhos pastures. Visited 2 X month from July to Feb (cut short by FMD, less on 2 enclosed sites), daylight observations only. Forage observation - two ponies for one hour per visit, with food choice recorded every 2.5 mins on moor, more general observations in enclosures. Registered and non-registered ponies.
Gordon 1989	Journal paper	Vegetation selection by a range of ungulates on Rhum, includes Highland ponies.
Groome & Shaw 2015	Journal paper	Replicate quadrats over 9 year. No site replicates. Statistical comparison of within and without cattle grazing exclosures on lowland wet heath and valley mire
Hester 1996	Report	Literature review for CCW. No examination of quality of literature reviewed.
King 2002	Journal paper	Przewalski horses re-introduced to the wild in Hustai National Park, Mongolia.
Lake 2002	PhD thesis	5 groups of livestock on 4 lowland heathland sites. Monthly observations for one year for each group for behaviour plus daily location records for habitat use. Different livestock types on different sites to cannot necessarily differentiate between site and livestock effects. However, not designed to provide a comparison of resource selection and between species (or breeds). Some statistical analysis
Lamoot 2004	Paper	Behavioural data were collected from Konik horses, Haflinger horses, Shetland ponies and donkeys, grazing in different nature reserves (54–80 ha).
Lamoot 2005	Paper	Habitat use by cattle and Shetland ponies in a scrub dominated Dutch dune system
Loucougaray 2003	Journal paper	6 year investigation of the impacts of monospecifc and mixed cattle and horse grazing on coastal wet grasslands with a history of mixed grazing, experiencing recent decline in horse grazing. Paddock, not extensive grazing, very low stock numbers, twice the number of (smaller) animals in mixed paddock.
Martin et al. 2013	NE evidence review	Evidence base review
Morel 2006	Journal paper	Monthly monitoring of physiological condition and forage type and intake correlated with environmental conditions (temperature, day length) in 5 stallions in Wales
Oates 1994	Report	Based on anecdotal information and observation plus questionnaire data

Authors	Publication type	Description
Perera 2004	Online abstract of conference talk/poster	Interim results from a study on the Isle of Wight looking at habitat preferences on two nature reserves of two non-breeding herds of New Forest ponies (10 and 7). Observations every minute for one hour 3 times a day (incl. after sunset) on 4 days per season per site
Petrie-Ritchie, 2015	Report	51 semi-structured questionnaires with farmers; ethograms of ponies. 51 pony keepers interviewed. Around 100 hrs of observations over several days at 3 sites, all daylight in May/June, including one newtake 1km sq. Compared contracepted, vasectimised and stallion removed groups but no replicates. Contracepted mares were in a newtake, not free ranging.
Plassmann et al. 2010	Journal paper	Long term monitoring of impact of Welsh Mountain ponies (CHECK) on sand dunes in North Wales.
Pollock 1980	report	Study of behaviour in welfare context. Observations, some statistical analysis.
Pratt et al. 1986	Journal paper	Based on counts at fixed points on transects (points checked every 2 hours for 24 hours, once a fortnight between jan and dec 1979 and behaviour noted. Use of Chi square to show non-random use overall.
Putman 1986	Book	Compilation of research carried out on herbivores of the New Forest, including the above and below papers.
Putman et al. 1987	Journal paper	Based on faecal analysis of cattle and pony dung in the New Forest, and direct observations of foraging livestock numbers and type on transect routes (points checked every 2 hours for 24 hours, once a fortnight between jan and dec 1986
Rigueira-Rodriguez	Journal paper	Randomised block design of two horse grazing treatments in Spanish pine forest over 4 years, two replicates
Seabrook, 2006	report	Observation of grazing impact correlated with measure of diversity at regenerating heath and rhos pasture site on Dartmoor
Steward & Eno 1998		Review of existing data, focussing on writing grazing plans
Tolhurst & Oates	Handbook	Largely based on anecdotal information obtained through contacting breeders and conservation managers
Tyler 1972	report	Behaviour of ponies in New Forest based on dawn to dusk observations of individuals and groups within a 3 mile recording area. Included half hourly records of activities of group. About 4000hrs of observations over 3 years, but few data present and no stats

Authors	Publication type	Description
Ward et al 1972	Journal paper	Description of vegetation of Dartmoor based on 34 transects with quadrats every 1km, association analysis used
Welch 1984 IV	Journal paper	Germination of seeds from cattle dung in glasshouse (from 12 sites) and in situ (3 sites) Part of wider project. Agricultural stocking rates of 1980