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Short Communication

Steep Holm Island, Bristol Channel, UK: evidence of *Larus fuscus* Linnaeus, 1758 (lesser black-backed gull) feeding on the invasive signal crayfish, *Pacifastacus leniusculus* Dana, 1852

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Abstract

The predation of invasive signal crayfish, *Pacifastacus leniusculus* (Dana, 1852) by several nesting pairs of lesser black-backed gull, *Larus fuscus* Linnaeus, 1758 is reported from Steep Holm (51°20.39' N, 3°6.53' W), one of two small islands located in the inner Bristol Channel, United Kingdom. This feeding activity was subsequently observed at a pond in South Wales.

Key words: crustacean; signal crayfish; *Pacifastacus leniusculus*; seabirds; lesser black-backed gull; *Larus fuscus*; predation; gastroliths

Introduction

Steep Holm (51°20.39'N, 3°6.53'W) is one of two small islands that mark the transition between the Severn Estuary and the Bristol Channel, United Kingdom (Figure 1), lying approximately 8 kilometres west of Weston-super-Mare in Somerset and 13 kilometres south of Cardiff. The privately owned island is a nature reserve and a Site of Special Scientific Interest, providing suitable conditions for nesting seabirds. The majority of gulls on the island are comprised of herring gull (*Larus argentatus* Pontoppidan, 1763), greater black-backed gull (*L. marinus* Linnaeus, 1758) and lesser black-backed gull (*L. fuscus* Linnaeus, 1758).

One of the duties of the island's warden is to maintain the pathways on the island. During August-September 2010 whilst mowing the path in the middle of the island, just metres from the Triangulation Point (Trig Point, which marks the highest point of the Island, 78 m, 51°20.35'N, 3°6.29'W) approximately 300 small white domed objects ca.15 mm in diameter were observed. They were scattered over the ground near a few old gulls' nests that were attributed to *L. fuscus*, which occupy this location, although one or two pairs of herring gulls have recently taken to nesting nearby. These discs stood out due to their brightness and abundance in such a discrete area. Again in 2011, while mowing in the same area, the warden noticed another 40 white discs, including one in a gull pellet. Despite gulls nesting over much of the island, these objects were restricted to a small group of bird nests and, in 34 years these were the only times they had been observed. Scattered too in this restricted area of nests around Trig Point were the remains of decapod exoskeletons (Figure 1, inset; Figure 3).

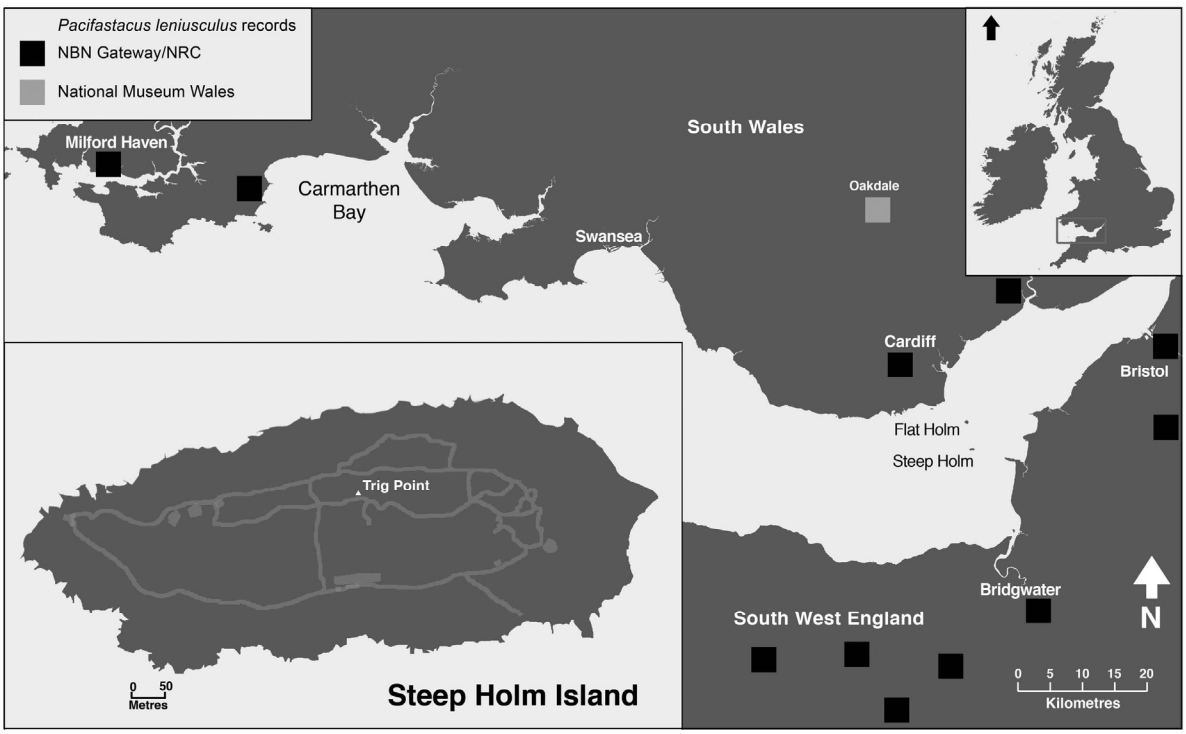

Figure 1. Steep Holm (51°20.39' N, 3°6.53' W) in the Bristol Channel, United Kingdom.

Abbreviations used: NMW (National Museum Wales, Cardiff), NHM (Natural History Museum, London).

Measurements taken: carapace length = from posterior carapace margin to tip of rostrum.

Gastroliths

The small white domed discs were identified as decapod gastroliths (Figure 2). Sometimes referred to as gizzard stones, stomach stones or crab's eyes, gastroliths are paired calcareo-phosphate accretions (Frizzell and Exline 1958). They are found on either side of the stomach immediately prior to moulting (ecdysis) in lobsters, crawfish, crayfish and some land crabs. For example, Farmer (1973: Figure 1c) provides a drawing showing the position of a gastrolith in the stomach of the Norway lobster *Nephrops norvegicus* (Linnaeus, 1758). Herrick (1911) reported a gastrolith of "an inch long, three-quarters of an inch wide, and a quarter of an inch thick" (25×19×6 mm) in an eleven inch (27.5 cm) American lobster, *Homarus americanus* (H. Milne Edwards, 1837). Lowery (1988: Figure 4.2) shows gastroliths from two adult *Pacifastacus leniusculus* and these are identical to those found on Steep Holm.

Gastroliths provide calcium (removed from the old exoskeleton) reserves for calcification of the cuticle after moulting (Scott and Duncan 1967). They are mainly made up of concentric layers of amorphous calcium carbonate (Travis 1963; Addadi et al. 2003), together with a chitin-protein organic matrix (Luquet 2011). The amount of calcium available from the gastroliths is insufficient for complete formation of the new exoskeleton (Lahti 1988), but is thought to be important in the initial calcification of essential body parts such as mouthparts and legs (Schechter et al. 2008).

Exoskeleton fragments

Comparative material examined: *P. leniusculus*, Pen-y-fan pond, near Cross Penmaen Industrial Estate, Oakdale, Gwent (51°41'55.96"N, 3°09'44.28"W), Wales; 1♀, 60.5 mm (NMW.Z. 2008.055.2); 1♀, 58.6 mm (NMW.Z.2008. 055.3); 1♀, 33.6 mm (NMW.Z.2008.055.3); *Austropotamobius pallipes* (Lereboullet, 1858),

Figure 2. Close-up of gastroliths collected from lesser black-backed gull nests at Triangulation Point, Steep Holm Island (Harry Taylor, NHM Photo Unit). Scale bar in mm.

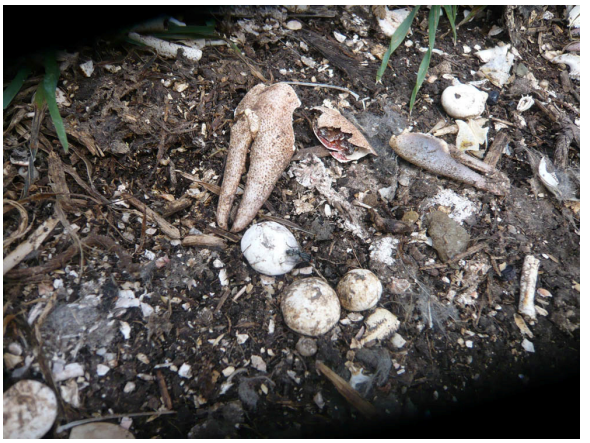

Figure 3. Gastroliths and chelae of signal crayfish, *P. leniusculus*, found associated with a gull nest on Steep Holm Island (51°20.39' N, 3°6.53' W), Bristol Channel, UK (Photo: Chris Maslen).

River Darent, Kent, England, coll. R.W. Ingle, 11.9.73, 1♀ (NHM 1973: 659).

Cheliped fragments found in the nest (Figures 3-4) were identified as those of the signal crayfish, *P. leniusculus* and confirmed through examination of comparative material from a pond in South Wales (Figure 5). They are considerably larger than those of the indigenous white-clawed crayfish, *A. pallipes* and the distinctive white coloration found at the junction of the propodus/dactylus in signal crayfish was still visible. All exoskeleton fragments are held at Steep Holm Exhibition Centre.

Crayfish distributions

The signal crayfish was introduced to the British Isles in the 1970s and had a major negative impact on the indigenous species (Holdich and Reeve 1991; Rogers and Watson 2011). As shown by the records (Figure 1) of the Biological Records Centre, and through the National Biodiversity Gateway (http://data.nbn.org.uk), this invasive species is now frequently found in South Wales and the north Somerset area. Other records in southwest Britain (Holdich and Sibley 2009) and South Wales suggest that the crayfish may well be more widely distributed around the Bristol Channel. In Wales, the indigenous crayfish is sparsely spread (Holdich and Sibley 2009). It is largely confined to the southeast, including the Wye and Usk rivers, and Grimstead and Brown (2012) note that, as elsewhere, populations have greatly diminished over the last 30 years. The greatest impact on the species comes from the signal crayfish and *Aphanomyces astaci* Schikora, 1906, the pathogenic water mould (Chromista: Oomycetes) that it carries and to which *A. pallipes* has no defence. Eradication of the larger and more aggressive invader may not be possible; hence control measures and conservation strategies for the indigenous species are receiving much attention (Freeman et al. 2010; Grimstead and Brown 2012).

The need for safe ark sites is now accepted as necessary for the survival of the indigenous crayfish (Peay 2009). Proposals suggest introductions could be made to isolated sites where *A. pallipes* populations were absent previously, such as former aggregate sites (Kindemba and Whitehouse 2009). Several ark sites are now established and further sites are planned in SW England (Robbins 2011; O'Neill and Whitehouse 2011; Sibley et al. 2011) and Wales (Grimstead and Brown 2012). A captive breeding trial has commenced at Bristol Zoo (Nightingale 2009), and in Wales a captive rearing programme has been established at the Environmental Agency's Cynrig Fish Culture Unit, near Brecon (Grimstead and Brown 2012).

Figure 4. Chelae of signal crayfish, *P. leniusculus*, collected from lesser black-backed gulls nests at Triangulation Point, Steep Holm Island. The superior propodal margin of chelped **d** appears to be a variation when compared to those of **a**, **b**, **c**. Whether this morphology is indicative of a juvenile signal crayfish or of another species is uncertain. Scale bar in mm. (Harry Taylor, NHM Photo Unit).

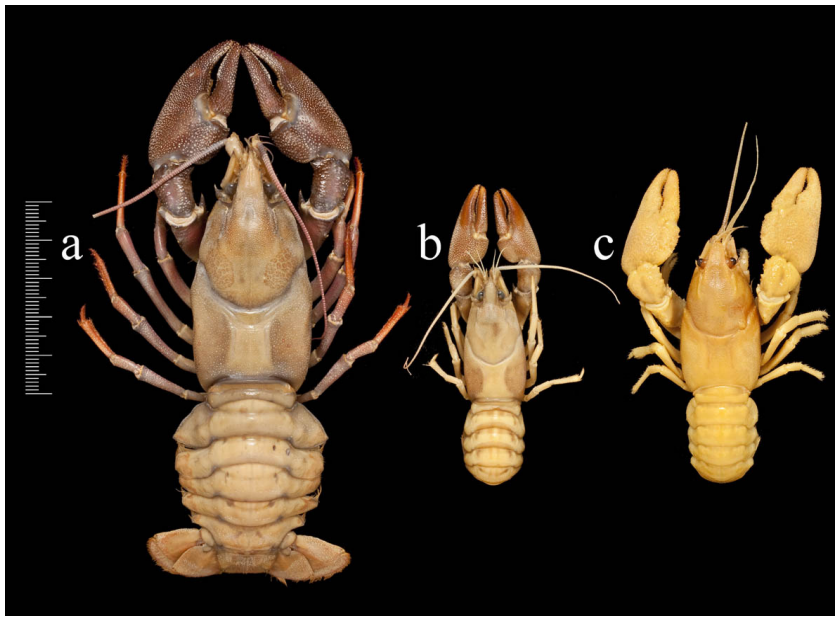

Figure 5. *Pacifastacus leniusculus*, Pen-y-fan pond, near Cross Penmaen Industrial Estate, Gwent (51°41'55.96"N, 3°09'44.28"W), Wales; **a**. 1♀, 60.5 mm (NMW.Z.2008.055.2); **b**. 1♀, 33.6 mm (NMW.Z.2008.055.3); **c**. *A. pallipes*, River Darent, Kent, England, coll. R.W. Ingle, 11.9.73, 1♀ (NHM 1973: 659). Scale bar in mm. (Harry Taylor, NHM Photo Unit).

Holdich and Sibley (2009) indicated that the UK now has seven crayfish species living in the wild, six being non-indigenous: *Procambarus clarkii* (Girard, 1852), *Orconectes limosus* (Rafinesque, 1817), *Orconectes virilis* (Hagen, 1870), *Astacus astacus* (Linnaeus, 1758), *Astacus leptodactylus* Eschscholtz, 1823, and *Pacifastacus leniusculus*. However, they considered only the last two to be widely distributed, with *P. leniusculus* having the most impact on the indigenous species.

Whilst databases are important records of species distributions, if they are not frequently revised than they can give incorrect impressions of the true distributions (Holdich and Sibley 2009). There is no accessible fresh water source to support crayfish on Steep Holm, hence the gulls must fly to the mainland. In South Wales, additional records of signal crayfish include Llwynon reservoir, Cyfarthfa Lake, and a storm drainage pond running into the Morlais Brook (Merthyr Tydfil area), Deri Lake and Parc Cwm

Darran Lake (Bargoed Valley), and Pontllanfraith (Tony Rees, Alison Jones and Ben Evans, pers. comm.). Crayfish surveys in Cardiff (Lamby Salt Marsh, Roath Brook and Llanishen Brook) for the River Rhymney and Nant Fawr Corridor Action Plan 2011-12 showed no signs of signal crayfish, however, they were discovered in the River Ely by the Environment Agency (River Ely Valley Action Plan 2011-12).

Bird predation

Wiltshire and Reynolds (2006) reported bird predation on the invasive Turkish crayfish, *A. leptodactylus* present in Serpentine Lake, Hyde Park, London. They photographed three species of bird eating crayfish: grey heron, *Ardea cinerea* Linnaeus, 1758, great crested grebe, *Podiceps cristatus* (Linnaeus, 1758) and lesser black-backed gull, *L. fuscus*. According to Wiltshire and Reynolds (2006) crayfish juveniles are desirable prey of trout, eels and perch, while adults are an important food source for otters and mink. However, the role of birds as predators of freshwater crayfish in Europe has not been well documented (Hogger 1988). Hogger stated that in Britain, the grey heron is probably the main avian predator of *A. pallipes* but they may be also taken by other opportunistic feeders such as carrion crow *Corvus corone* Linnaeus, 1758, tawny owl *Strix aluco* Linnaeus, 1758 and kingfisher *Alcedo atthis* (Linnaeus, 1758).

Coots (*Fulica atra* Linnaeus, 1758) have been observed feeding on the spiny-cheek crayfish, *Orconectes limosus*, on the banks of Clifton Pond, near Nottingham (Holdich and Black 2007). The crayfish were introduced there by a carp angler. Whilst kingfishers were seen on the Halcyon River, Somerset actively catching and feeding signal crayfish to their young when fish were difficult to catch (BBC television's 'Tales from the Halcyon River' series).

Crayfish rarely form more than a minor part of the diet of a predator, and they are often a seasonal food source (i.e., when they are juveniles, or just after moulting) (Hogger 1988).

Diet of *Larus fuscus*

Dierschke and Hüppop (2003) found that diet of juvenile *L. fuscus* on Helgoland was predominately comprised of fish (76% fishery discards) and rarely on crustaceans. Kubetzki and Garthe (2003) found that the diet of *L. fuscus* in the southeastern North Sea principally comprised of fish and crustaceans, and that they predominantly fed at sea. This may have been to avoid competition with the other sympatrically breeding species in the area (*L. ridibundus* Linnaeus, 1766, *L. canus* Linnaeus, 1758 and *L. argentatus*). Additionally, Schwemmer and Garthe (2005) found that *L. fuscus* in the same area were predominately feeding on swimming crabs (*Liocarcinus* spp.), a natural food source captured close to the shore. However, when feeding at longer distances they fed mainly on other natural prey items or discarded fish from trawlers, avoiding competition with other breeding gull species. They suggested that the food choice of *L. fuscus* may change during the season due to food availability (abundance and accessibility) or because of the need of specific nutrients such as calcium, which is important for eggshell production and chick bone development. This view is supported by Norwegian studies (Bustnes et al. 2010) that regarded the gulls as generally piscivorous in the breeding season, but likely to exploit other prey when fish were unavailable. Interestingly, Oro (1996) showed that *L. fuscus* in the western Mediterranean exploited the American crayfish, *P. clarkii* as a food resource when other preferred food sources, from fishery discards and rice fields were not available.

Feeding observations

A visit to Steep Holm during this breeding season (June-July 2012) was not undertaken due to poor weather and therefore no direct feeding observations from the island were possible. As an alternative, one of us (ASYM) made five 1.5-2.5 hour visits to Pen-y-fan Pond (12-15 July 2012); 4 morning (starting 06:00-08:00) and 1 evening (20:00). Pen-y-fan Pond is known to have had a large population of signal crayfish for at least 8 years (Ben Evans and Alison Jones, pers. comm.), and is the location for the comparative material examined above (Figure 5). Photographs posted on the satellite view of the 14 acre pond on Google Maps (http://maps.google.co.uk) show a variety of birds including lesser black-backed and herring gulls.

A solitary lesser black-backed gull was the only gull seen at the pond during each morning visit (Figure 6, insets **a** and **b**). No gulls were seen on the wet evening occasion. The gull only

Figure 6. *Larus fuscus* Linnaeus, 1758 at Pen-y-fan Pond. Background, gull searching shallows, "X" marks position of crayfish capture; Insets, **a**. at rest; **b**. in flight; **c**. with signal crayfish, extreme crop from full zoom photograph (55-250 mm Canon lens) taken using a Canon 550D camera at estimated 140 m distance (Photos: Andy Mackie).

persisted in searching for food on the morning of July 12, the most sunny day, carrying out about eight partial or complete circuits of the pond. The bird flew at a height of 10-15 m (Figure 6), occasionally doubling back and swooping to 3-5 m. There was only one occasion when the bird was in view that it dived into the water. This was unsuccessful, the gull however remained on the water and soon dived again, surfacing with a crayfish in its beak (Figure 6, inset c). The depth of water at the estimated position (51°41'52.8354" N, 3°9'49.4994"W), 140 m from the viewing point, was about 30-40 cm.

Discussions with three anglers over the 4-day period revealed that all had noticed a scarcity of crayfish this year. Previously, they all recalled abundant crayfish crawling over the toes of their waders and, on occasion, even getting on their lines. One angler said that he and two friends had watched a gull catching several crayfish over a 15 minute period on a bright sunny morning the previous week; the others had never noticed gulls feeding. This account and direct observation indicate that the gulls do consume crayfish at the site of capture.

Conclusions

The feeding of lesser black-backed gulls on Steep Holm Island is of interest as the birds have had to forage for invasive signal crayfish in rivers further afield on the mainland (somewhere in the Somerset to South Wales arc). Ratcliffe et al. (2000; cited in Langston 2010) considered the lesser black-back to forage up to 40 km from their nests. This would indicate that crayfish populations east of Bristol, west of Bridgwater and as far north as Oakdale in South Wales (see Figure 1) would be accessible to the gulls. Birdlife International has been compiling a database of seabird foraging ranges since 2007.

The database is accessible online (http://seabird.wikispaces.com/) and currently cites a maximum range of between 44 and 84 km from a small GPS tracking study.

Judging by the number of gastroliths found in the gull nests, *P. leniusculus* appears to be established as a good food resource for several pairs on the island. No previous report of gull predation on this invasive species is known. Will other gulls nesting on Steep Holm Island (and elsewhere) copy this behaviour and increase exploitation of this abundant and unwanted freshwater crayfish? The origin of the bird seen feeding on signal crayfish at Pen-y-fan Pond is not known. Furthermore, if gulls are able to fly long distances to prey on crayfish, this could have implications for the safety of *A. pallipes* in ark sites.

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