

Rapid Communication**First records of the pitcher plant mite *Sarraceniopus gibsoni* (Nesbitt, 1954) (Astigmata: Histiostomatidae) in Europe**Ellen L. Goddard^{1,*}, Robert Naczi², Kevin Walker³, Jonathan Millett¹ and Paul J. Wood¹¹Geography and Environment, Loughborough University, Loughborough, Leicestershire, LE11 3TU, UK²New York Botanical Garden, 2900 Southern Blvd, Bronx, NY, 10458-5126, USA³Botanical Society of Britain and Ireland (BSBI), Room 14 Bridge House, 1-2 Station Bridge, Harrogate, HG1 1SS, UK

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Received: 28 October 2020**Accepted:** 23 August 2021**Published:** 22 November 2021**Handling editor:** Laura Garzoli**Thematic editor:** Angeliki Martinou**Copyright:** © Goddard et al.This is an open access article distributed under terms of the Creative Commons Attribution License ([Attribution 4.0 International - CC BY 4.0](https://creativecommons.org/licenses/by/4.0/)).**OPEN ACCESS****Abstract**

The carnivorous pitcher plant *Sarracenia purpurea* has been introduced across Europe from North America. Thus far, whether the inquiline species intimately associated with *S. purpurea* have also been introduced had not been studied. *Sarraceniopus gibsoni* is the obligate mite species found in *S. purpurea* and is ubiquitous within the pitchers in North America. Three sites in Britain and Ireland were sampled. Two of the three sites were confirmed to support *S. gibsoni* populations, one site in Ireland and one in England. The presence of *S. gibsoni* suggests that living plants of *S. purpurea* had been introduced to the sites hosting mite populations.

Key words: *Sarracenia purpurea*, inquiline communities, non-native, invasive, unintentional introduction, obligate species

Introduction

Pitcher plant mites in the genus *Sarraceniopus* (Astigmata: Histiostomatidae) are obligate inhabitants of plants in Sarraceniaceae. Sarraceniaceae are carnivorous plants with tubular shaped leaves called “pitchers” that are adapted to attract, trap, digest, and absorb nutrients from a wide variety of prey animals, usually arthropods (Naczi 2018). Despite the effectiveness of these traps, a small number of arthropod species are able to inhabit and thrive in the fluid within the pitchers (Addicott 1974; Heard 1994; Bledzki and Ellison 2003). *Sarraceniopus* mites complete their life cycles only within Sarraceniaceae pitchers and are part of the detritivore food web facilitating prey “digestion” by feeding on bacteria and particulate organic matter from captured prey (Baiser et al. 2013). Only for very brief periods, to facilitate dispersal, do the mites ever leave the pitcher (Naczi 2018).

Sarraceniopus gibsoni (Nesbitt, 1954) is an obligate associate of *Sarracenia purpurea* L. living in its rain-filled pitchers (Naczi 2018). Nesbitt (1954) described the species, as *Zwickia gibsoni*, from collections he made from inside *S. purpurea* pitchers in Nova Scotia, Ontario, and Québec, Canada. Later, Fashing and OConnor (1984) described *Sarraceniopus* as a new genus

for histiostomatid mites living inside pitchers of Sarraceniaceae and transferred the species to the genus as *Sarraceniopus gibsoni*. Other obligate arthropod associates of *Sarracenia purpurea* are aquatic larvae of the pitcher-plant mosquito *Wyeomyia smithii* (Diptera: Culicidae), the pitcher plant midge *Metriocnemus knabi* (Diptera: Chironomidae) and the sarcophagid fly *Fletcherimyia fletcheri* (Diptera: Sarcophagidae) (Addicott 1974; Heard 1994; Bledzki and Ellison 2003). *Sarracenia purpurea* is native to the eastern U.S.A. and much of Canada. Within this range, *S. gibsoni* is ubiquitous in *S. purpurea*, at landscape, population, plant, and pitcher scales (Buckley et al. 2010). *Sarraceniopus gibsoni* is usually abundant in *S. purpurea* pitchers. Given their ubiquity and abundance, it is likely that the mites have a significant impact on the food web within the fluid of *S. purpurea*. *Sarraceniopus gibsoni* may be a mutualist, as documented for other arthropod symbionts of *S. purpurea* (Bradshaw and Creelman 1984). Other arthropod symbionts typically feed on the fragmented prey, accelerating nutrient digestion by the host. *Sarraceniopus gibsoni* appears to do the same, which is hypothesized to make nutrients more readily available to the host plant.

Sarracenia purpurea has been deliberately introduced at over 100 sites across North West Europe (including Sweden, Switzerland, France, Germany, UK and Ireland), and at a small number of sites in Japan and New Zealand (Adlassnig et al. 2010; Pyšek et al. 2012). On some of these sites *S. purpurea* has become invasive reducing the abundance of native vascular plants and bryophytes (Walker 2014). The commercial availability of *S. purpurea* has increased in Europe within recent years, with it now being readily available within the horticulture trade, including garden centers. This makes probability of introduction into the wild even greater.

The extent to which *S. gibsoni* has been unintentionally introduced alongside *S. purpurea* is currently unknown. Other species of *Sarraceniopus* are confirmed as introduced in Japan in unidentified, cultivated *Sarracenia* hybrids (Tagami 2004). Given the ubiquity of *S. gibsoni* in *S. purpurea* pitchers in its native range, understanding whether the mite is present within the pitchers in its non-native range is important for understanding pitcher plant ecology, and how its ecologic roles may be modified when introduced outside of its native range, especially in the areas where it may become invasive. *Sarracenia purpurea* is known in some situations to have been deliberately introduced into Europe as living plants, and in other situations from seed (Wulf 2008). Introduction of living plants presents the potential for the unintentional co-introduction of *S. gibsoni*, but such a possibility has yet to be confirmed. The aim of the current study was to determine whether *S. gibsoni* is present in non-native, European populations of *S. purpurea*.

Materials and methods

Three populations of *S. purpurea* were chosen across Great Britain and Ireland to provide a wide geographical spread: one in northern England



Figure 1. Pictures showing the three sampled populations of *S. purpurea* across Great Britain and Ireland. A – population located in Cumbria in the UK, B – population located in county Offaly in central Ireland, and C – population located in Dorset England (photo credit: Ellen Goddard).

(Cumbria), one in southern England (Dorset) and one in the Republic of Ireland (Offaly) (Figure 1, Table 1). These populations were chosen as *S. purpurea* was introduced more than twenty years ago making the populations well established and regenerating within each site (Walker 2014). Sampling was undertaken during August 2019. Within each site 20 pitchers (from separate rosettes) were sampled. The sampled pitchers were the present year's new pitchers. Only fully mature pitchers were sampled for there to have been time for colonisation of pitchers by arthropod associates. Cumbria and Offaly's pitchers were sampled along a transect across

Table 1. Site descriptions of the three sampled sites.

Location	Introduction date*	Bog type	Population size (no. ramets)	Mean annual temperature (°C)*	Mean annual precipitation (mm)**	Latitude; longitude
UK – Cumbria	1963	Minerotrophic valley mire	200	9	904	54.40; –2.98
Ireland – Offaly	1930	Ombrotrophic raised bog	100,000+	9.9	794	53.37; –7.62
UK – Dorset	1998	Minerotrophic valley mire	100	8.3	1067	50.72; –2.16

* data extracted from Walker 2014.

** data extracted from Worldclim (Hijmans et al. 2005).

the entire population, roughly a 30 m and 100 m transect respectively. Following removal of the majority of the population for site management purposes, the site in Dorset is small (c. 100 plants) and restricted to permanent monitoring plots. Sampling was therefore undertaken randomly within five separate square plots. Pitchers were individually removed and liquid from each individual pitcher was poured into a 50 ml falcon tube and preserved by adding equal amounts (to the individual pitcher fluid) of 70% ethanol.

Samples were assessed to determine presence or absence of mites in a laboratory using a Zeiss dissecting microscope (40x magnification). Where mites were present, a subset from each population were sent to New York Botanical Garden for confirmation of identification of *S. gibsoni*. Key identification characteristics for *S. gibsoni* are claws elongate (> 30% length of adjacent tarsi), palp lacking setae, palpal solenidion rigid, and chelicerae short (about as long as tibia I), in all feeding (non-deutonymphal) stages of the life cycle (Nesbitt 1954; Fashing and OConnor 1984; Figure 2).

For identification, mites were cleared with Nesbitt's fluid, mounted in Hoyer's medium on microscope slides, and studied with light microscopy (Walter and Krantz 2009). Slide-mounted voucher specimens of *Sarraceniopus gibsoni* are deposited in the collection of the Division of Invertebrates of The Natural History Museum, London and in the collection of the second author.

Results

We confirmed the presence of *S. gibsoni* within *S. purpurea* pitchers in two of the three sites sampled. These were the sites in Dorset UK and in Offaly Central Ireland (Figure 3). Despite a comprehensive search of material sampled from pitchers growing at the Cumbria UK site, no *S. gibsoni* were recorded in any of the 20 samples collected and examined. We, therefore, consider it likely that *S. gibsoni* is absent from this site.

Sarraceniopus gibsoni were recorded in all pitchers examined from Offaly and Dorset, and abundance within individual pitchers was typically high (> 20 at Offaly and > 50 individuals per pitcher at Dorset when arthropod prey remains were present in the fluid). Individuals were observed clinging to the surface of arthropod remains and freely within the pitcher fluid. Given the nature of sampling in the field, some individuals almost certainly



Figure 2. *Sarraceniopus gibsoni* female. Scale bar = 100 μ m (photo credit Robert Naczi).

remained within the pitcher after sampling and therefore the abundances recorded are a minimum estimate of the population within each pitcher.

Discussion

These are the first records of *S. gibsoni* from Europe and the first record of any obligate arthropod associate of *S. purpurea* in Europe. The presence or absence of obligate species in *S. purpurea* pitchers is important because of the role they can play in the community structure within the food web (Buckley et al. 2010). Due to how abundant *S. gibsoni* is in pitchers in the native range it is suspected these mites play an important role within the pitcher food web and impact nutrient availability, although this is not yet confirmed. Prey nutrient uptake is an important component of *S. purpurea* ecology and may contribute to the invasive nature of the plant in some situations when introduced. Knowing where obligate associates are present or absent is therefore important and provides a more comprehensive understanding of *S. purpurea* introductions.

The null record for the Cumbrian site presents an interesting opportunity to advance understanding of the functional role of obligate species in-situ. *Sarraceniopus gibsoni* is abundant and ubiquitous at all landscape scales in

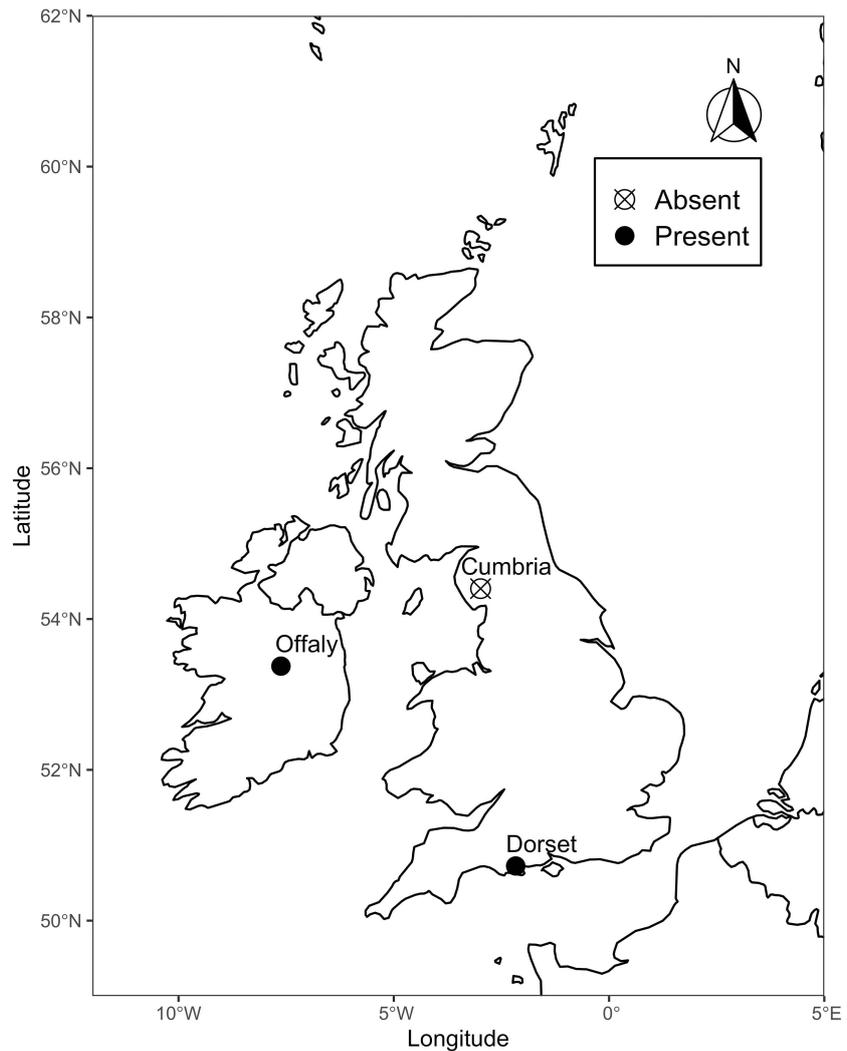


Figure 3. Map showing sites sampled across Great Britain and Ireland. Filled circles represent sites where *S. gibsoni* was confirmed as present. Circle with a cross represents the site at which we did not detect *S. gibsoni*.

its native range (Buckley et al. 2010) and is predicted to have an important impact on the carnivorous function of *S. purpurea*. The presence of *S. gibsoni* may also reveal information about the history of *S. purpurea* introductions. For example, it is highly likely that *S. gibsoni* will be introduced every time that *S. purpurea* is introduced using whole/living plant material. As a result, where *S. gibsoni* is present we predict that the *S. purpurea* introduction was from at least one whole plant, with or without seed introductions as well. In contrast, the absence of *S. gibsoni* from a site where *S. purpurea* has been introduced potentially indicates the introduction was from seed. However, it was previously thought the Cumbria population was introduced from plant material. It is recorded that many populations of *S. purpurea* in Ireland (including the site we sampled), have been established from translocated plants originating from one main site (Taggart et al. 1990). This suggests that *S. gibsoni* may be widespread in Irish populations. There are, however, other hypotheses of how *S. gibsoni* has been introduced to these European sites. As there has not been a full survey of these sites for *S. gibsoni* it may

be that *S. gibsoni* is present within similar environments (such as tree holes) and the pitchers and then colonised rather than introduced with the plants themselves. It may be that *S. gibsoni* populations may exist elsewhere in ornamental or laboratory plant populations and disperse via phorsee into the established *S. purpurea* populations. While we cannot yet rule out these possibilities for *S. gibsoni* introduction, we expect this mite species is more likely to have been introduced with *S. purpurea*.

To fully understand the biogeography of *S. gibsoni* within Europe a more comprehensive sampling campaign is required. This would be facilitated through the use of DNA metabarcoding, once a reference library for *S. gibsoni* is available. We predict that *S. gibsoni* is widespread across *S. purpurea* populations in Europe, indicating naturalisation facilitated by the naturalisation of a non-native host species.

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Authors' contribution

RN, JM, KW, EG: research conceptualization; RN, JM, KW, EG: sample design and methodology; EG, RN, PW: investigation and data collection; EG, PW, JM, RN: data analysis and interpretation; EG: ethics approval; EG, KW, JM: funding provision; EG, KW, PW, RN, JM: roles/writing – original draft, writing – review and editing.

Ethics and permits

Two of the sites were privately owned and landowner permission was verbally granted. The Dorset site permit was provided by the Forestry Commission through the South England Forest District for permission to undertake a scientific/wildlife/ecological study. Permit number 022477/2019 file ref rec. 12/1.

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