Two wetland-specific Lepidoptera new to Portugal, with notes on ecology, life history and conservation

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Abstract

Two wetland-specific moths are documented for the first time in Portugal: *Globia algae* (Esper, 1789) (Lepidoptera: Noctuidae) and *Friedlanderia cicatricella* (Hübner, 1824) (Lepidoptera: Crambidae). Surveys conducted at Lagoa de Óbidos, and later extended to additional localities, provided additional data on their ecology and life histories. Both species are associated with tall helophyte communities characterized by large stands of *Schoenoplectus lacustris* (L.) Palla s.l. The results highlight the importance of dynamically stable micro-sites in wetlands, and support approaches that integrate rural land use with biodiversity conservation.
Keywords: Noctuidae, Crambidae, Apameini, wetlands, host-plants.

Resumo

Duas espécies de lepidópteros de hábitos palustres são documentadas pela primeira vez em Portugal: *Globia algae* (Esper, 1789) (Lepidoptera: Noctuidae) e *Friedlanderia cicatricella* (Hübner, 1824) (Lepidoptera: Crambidae). Levantamentos populacionais realizados na Lagoa de Óbidos e posteriormente alargados a outras localidades, fornecem dados adicionais sobre as suas ecologias e ciclos de vida. Ambas as espécies estão associadas a comunidades de grandes helófitos caracterizados por tufos densos de *Schoenoplectus lacustris* (L.) Palla s.l. Os resultados destacam a importância de microssítios dotados de estabilidade dinâmica em zonas húmidas, apoiando abordagens que integrem as atividades rurais com a conservação da biodiversidade.
Palavras-chave: Noctuidae, Crambidae, Apameini, zonas húmidas, plantas hospedeiras.

Introduction

Knowledge of Lepidoptera in Portugal has been hindered by the cryptic and localized nature of many species. Traditional light-based sampling often fails to detect such populations within dynamic and heterogeneous ecosystems, highlighting the need for more comprehensive and targeted methodological approaches.

Since 2014, several rare populations have been monitored in the remaining natural habitats of central-western Portugal by following their host-plants. The botanical framework supporting these surveys was later strengthened through contributions by the author to the Red List of Vascular Flora of Mainland Portugal, particularly for the Lagoa de Óbidos region (Carapeto et al., 2020; Farminhão et al., 2021).

Subsequent fieldwork revealed several noteworthy findings, identifying the presence of two nocturnal endophytic moths previously unrecorded in the country: *Globia algae* (Esper, 1789) and *Friedlanderia cicatricella* (Hübner, 1824). Both species are associated with tall helophyte communities of the class *Phragmito-Magno-Caricetea* (Landucci et al., 2020), dominated by *Schoenoplectus lacustris* (L.) Palla s.l., which was the only plant on which oviposition was observed.

Given their status as new records for Portugal, their specialized ecology and the scarcity of Iberian records (Farino et al., 2024), these species warrant particular attention, particularly given their tendency toward fragmented distributions and high vulnerability to anthropogenic pressures. Using a multi-approach research framework, this study documents the first national records of these taxa, aims to provide an initial assessment of their populations, and to offer a preliminary evaluation of their conservation status.

Material and methods

Field sessions were conducted across geographically distant municipalities to assess preliminary distribution and abundances. Observations of phenology, ecology, ethology, and host-plant interactions were compared across three Portuguese provinces, and biological material was collected for further research.

Municipalities covered by field sessions:

- Western Coast (Leiria): Alcobaça, Bombarral, Caldas da Rainha, Leiria, Marinha Grande, Nazaré, Óbidos, Peniche.
- Beira Litoral (Coimbra): Figueira da Foz.
- Ribatejo (Santarém): Golegã.
- Setúbal: Santiago do Cacém.

Natural Reserves and protected areas (Rede Natura 2000):

- Reserva Natural do Paul do Boquilobo (UNESCO Biosphere Reserve)
- Reserva Natural das Lagoas de Santo André e da Sancha (SPA; SAC - Natura 2000)
- Reserva Natural Local do Paul de Tornada (Ramsar Site)
- Mata Nacional de Leiria (PGF)
- Dunas de Mira; Gândara e Gafanhas (SAC - Natura 2000)

On-site trapping was employed as an auxiliary method occasionally, utilizing a set of three 10 W mini-projectors (365 nm UVA, unfiltered) mounted on a tripod (Fig. 1) against a white sheet or an aluminum-coated tarpaulin.


Fig. 1 - On-site trapping at Lagoa da Vela left on a bank; close to *S. lacustris* stands, while also inspected directly with handheld flashlights.

Direct observation with high-power handheld flashlights yielded the best results: long-wavelength emitters (deep red light - 660 nm) were used to minimize nocturnal disturbance, while high-power short-wavelength emitters (UVA) were effective for immobilizing fleeing moths, facilitating their identification. For perching insects and larvae, all-around white light flashlight proved to be the most effective tool.

Observations were semi-quantitative and based on repeated standardized field visits, with survey effort controlled by time and area covered per visit in a small pond near Poça do Vau (Lagoa de Óbidos). Sampling sessions were conducted over a two-and-a-half-year period. For the adult stage, surveys were carried out at least four times per week on alternate days during 2024, from May to August, coinciding with the mating seasons of both species and starting at dusk. The most intensive fieldwork took place that year, extending into spring 2025 for the larval stage. In subsequent years, the knowledge gained allowed for less intensive sampling in the water and more efficient surveys from the banks, as a preventive protective measure.

Survey routes ranged from -2 to 50 meters in altitude, primarily across waterlogged areas. Fixed narrow tracks through vegetation were followed, and the systematic or prolonged use of white and UV light was strictly minimized in sensitive areas to reduce environmental impact.

Image documentation was carried out by a Canon EOS 6D with a 100 mm macro lens, employing improvised flash setups with diffusers. Images were later edited in Adobe Lightroom to approximate the field view.

For the host-plants, taxonomic identification was based on the morphological criteria of *Flora Iberica* (Luceño & Jiménez-Mejías, 2008), although adopting the nomenclature of the group (Lansdown, 2020), where *Schoenoplectus lacustris* (L.) Palla s.s. and *S. tabernaemontani* (C.C. Gmel.) Palla are treated as distinct species. However, as noted by the latter author, morphological differentiation is frequently obscured by the presence of the hybrid *Schoenoplectus* × *flevensis* (D.Bakker) Lansdown & Rumsey, which exhibits overlapping characters. In our study, while moth populations were pragmatically considered associated with the parental species, the niche and morphology occasionally overlaps and suggests that host selection may occur across the wider species complex.

Results

Alongside many remarkable riparian and wetland moths, two unexpected discoveries stand out as new records for the country, having likely been overlooked in previous national studies.

Occurring in syntopy, both are associated with aquatic environments, sharing the same main host-plant and an endophytic oviposition, in areas that remain temporarily flooded until the end of the breeding season (from May to late July in western Portugal). In figs. 2 and 3 they are represented by mating pairs, with the females positioned above.

Globia algae (Esper, 1789) - The first Portuguese records of this wetland noctuid originate from Lagoa de Óbidos - Poças do Vau (Óbidos), 29S MD8158, 20.v.2024 (larvae, reared); Reguengo da Parada (Caldas da Rainha), 29S MD8769, 21.v.2024 (larva, reared), where active imagines were also detected days later. Subsequently, records were obtained at two more localities of recognized conservation importance: Reserva da Biosfera do Paul do Boquilobo (Azinhaga), 29S ND4060, 7.vii.2024 (male), and Reserva Natural das Lagoas de Santo André e da Sancha (Santiago do Cacém), 29S NC1614, 10.vii.2024 (male).

Fig. 2 – Mating pair of *Globia algae*.

Friedlanderia cicatricella (Hübner, 1824) - A large crambid associated with marsh and salt-marsh habitats, occupying (often sharing) a similar feeding niche to that of *G. algae*.

Previously mentioned in the Vives Moreno (2014) catalogue without date or locality, this species was not accepted in the national Lepidoptera list because of absence of data (Corley, 2015). The observation at Lagoa de Óbidos, Poças do Vau (Óbidos), 29S MD8158, 18.v.2024, now represents the first documented record for the country (female). It was later recorded in high numbers at the Reserva da Biosfera do Paul do Boquilobo (Azinhaga), 29S ND4060, 6.vi.2024, and sporadically in ditches within floodplains near Chão da Parada (Caldas da Rainha), 29S MD8769, 12.vi.2025. However, it was not detected at Lagoas de Santo André e da Sancha, perhaps because the single survey took place after the seasonal peak and during late-night hours.

Fig. 3 - Mating pair of *Friedlanderia cicatricella*.

To date, three disjunct populations of *G. algae* have been identified in Portugal: the Caldas da Rainha Typhonic Valley (Lagoa de Óbidos and Chão da Parada flood plains), Paul do Boquilobo, and Lagoas de Santo André, which are likely isolated from one another (Fig. 4).

In the coastal regions of the Coimbra district (Dunas de Mira; Gândara e Gafanhas) and Leiria (Mata Nacional de Leiria), surveys produced negative results, with no individuals or interactions recorded during the study period.

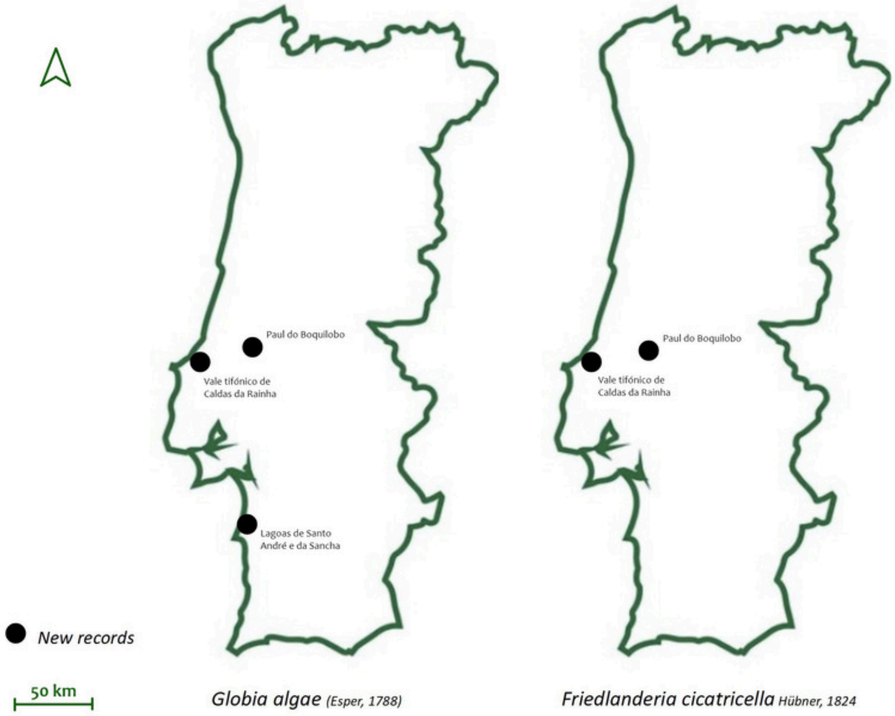

Fig. 4 - Known distribution of *G. algae*, *F. cicatricella* in Portugal (2024).

National distribution maps for the host-plants are available on the Flora-On portal (Flora-On, 2025), which aggregates reliable data from multiple sources.

Due to the erratic flight patterns and high density of individuals in marshy habitat, exhaustive photographic documentation and simultaneous field notation were logistically constrained. Consequently, the hundreds of observed interactions were recorded as real-time visual estimates, with the photographic archive providing a representative subset for taxonomic validation.

A short selection of records is listed at the end of this publication.

Part of the biological material (*G. algae*) is deposited in the José Luis Yela collection (Spain), with additional specimens in the author's private collection (both species).

Discussion

Within the three known disjunct populations of *G. algae* (Caldas da Rainha Typhonic Valley, Paul do Boquilobo and Lagoas de Santo André), the species appears to form metapopulation systems in Paul do Boquilobo and the Caldas da Rainha Typhonic Valley. These are characterized by core populations in a metapopulation context (high density of larvae and breeders annually), residing in small high-quality patches, that likely function as source populations, supporting smaller satellite populations in nearby locations. At Lagoas de Santo André, data are currently insufficient to characterize its population dynamics.

Two micro-sites can be considered hotspots for the species, as core populations:

- A small vestigial pond not far from the large Poça do Vau (Lagoa de Óbidos), dominated by *Schoenoplectus lacustris* (L.) Palla., featuring other tall helophytes in the background. The relative abundance of both moths is significantly higher than at Grande Poça do Vau, located just a few hundred meters away, where dense stands of the hostplant also occur.

- A highly restricted (protected) temporarily flooded area within Reserva da Biosfera do Paul do Boquilobo, featuring large stands of *S. palustris* in deeper areas, closely surrounded by the endangered *Butomus umbellatus* L., several medium-sized nitrophilous alien annuals, and extensive carpets of *Paspalum distichum* L. which seasonally function as a buffer filtering excess nutrients.

Fig. 5a/b

a) Small ancient pond dominated by *S. lacustris*, drying out during the summer (26.iv.2021).

b) Very temporary but exceptionally high water levels were recorded on 12.ii.2026, following the Kristin depression.

The site is surrounded by *Eucalyptus* plantations near the large Poça do Vau. Once part of the Lagoa de Óbidos water surface, the pond is now fed by cryptic overland flow (retaining permanent humid soil during summer). After being completely severed by a road, it became a small stronghold in a forgotten roadside corner, only occasionally reached by temporary floods. Despite its reduced size, it hosts high numbers of *Globia algae* and *Friedlanderia cicatricella*.

In contrast to the Lagoa de Óbidos (largely surrounded by privately owned land), Paul do Boquilobo, and Reserva Natural das Lagoas de Santo André e da Sancha, are subject to active habitat management and hydrological monitoring, outlined in the recent 'Plano de Cogestão', these actions prioritize the conservation of such increasingly rare wetland ecosystems (cf. ICNF, 2024).

The findings highlight the significance of Portuguese marshlands as natural heritage and suggests informed management decisions. Effective conservation depends on an integrated, ecosystem-based approach that explicitly incorporates host-plant ecology and habitat dynamics, as these form the basis for understanding the associated Lepidoptera species.

Broad expanses of tall-helophyte communities still persist in the studied localities, but the specific associations comprising large stands of *S. lacustris* s.l. (crucial for these moths) are actually highly fragmented.

National distribution maps show many coastal occurrence sites for *S. lacustris* s.l., such as the Baixo Mondego or Ria de Aveiro regions (although excluded from this study). However, the plant's presence does not guarantee the moths' occurrence; in Vale Tifónico de Caldas da Rainha (the starting point for the study area), both species are absent from many suitable sites, likely due to anthropogenic pressures disrupting their life cycles. However, instances of discontinuous occupancy across a vast territory and fragmented habitat are possibly due to historical natural factors, such as the establishment of pioneer plants without their associated biodiversity, or the isolation of regions geographically distant from core populations.

I - Dynamic stability across environmental heterogeneity:

The habitat of *G. algae* and *F. cicatricella* may exhibit diverse geological profiles, reflecting the broad substrate tolerance of their host plant. This tolerance ranges from flooded sandstone to heavy clay, with instances where a single nucleus extends across ecotones of both types.

At Lagoa de Óbidos, *S. lacustris* s.l. thrives under slightly brackish influence (ranging from sites with strong to minimal or non-existent tidal action) as well at the intersection of acidic flows with carbonate-rich waters, within ditches, seasonal floodplains and small ponds. At Boquilobo, geologically and edaphically less diverse, the hardness and alkaline influence is even more pronounced due to Tagus alluvial aquifer (cf. Almeida et al., 2000; ICNF, 2024), leading to significant calcium carbonate precipitation at the base of the plant stalks.

Notwithstanding the plants' relative tolerance and the significant phenological plasticity, and despite the escalating pressures that add more variability, a fundamental ecological stability seems to remain essential. This ensures the precise phenological synchrony between host-plants and moths, high nutritional intake for the larvae, still enabling vigorous plants to withstand high densities of stem borers over consecutive years.

In the study area, some of the *Schoenoplectus* s.l. population nuclei may exhibit a reversed phenology, whereas they had been monitored in previous years coinciding with that of the local core populations. This shift has been identified as an important threat in terms of habitat reduction.

A good example of this is a nucleus near Pequena Poça do Vau, despite the absence of obvious physical damage, initiates its vegetative cycle in late summer and reaches maturity in autumn, leaving virtually no organic traces during the rest of the year. When cultivated in a controlled nursery environment, this plant reverts to an almost standard vegetative period (Lemos, P., pers. obs.). The causes of this discrepancy remain unclear, but it is likely related to local environmental conditions such as water chemistry, organic load or turbidity, which are known to influence helophyte growth and phenology (Clevering, 1998a, b; Coops et al., 1996; Menéndez et al., 2000), potentially creating a 'toxic window' that may force the plants to alter their phenophases.

Fig. 6 – Impact of occasional autumn sheep grazing on *S. lacustris* stands prior to heavy rainfall. Animals follow established tracks, selectively grazing on green, leafy vegetation in humid soil (e.g., the partially grazed *Sparganium erectum* in the center) while leaving approximately 70% of the dry *S. lacustris* stands intact. This grazing results in variable physical damage due to trampling. Poça do Vau (Óbidos, x.2025).
The effect of non-equine livestock on *S. lacustris* appears less significant than on other spreading helophytes, such as *Phragmites australis*, which are known to dominate shallow water levels in the absence of defoliation.

Not every pond with S. lacustris provides the necessary conditions to align the life cycles of host-plants and their inquilines. Whether driven by genetics or shaped by stochastic environmental factors, the phenological synchrony between host-plants and these moths is critical to the success of their interaction.

II - Insights on tall-helophyte communities and herbivory:

Favorable habitat for the studied lepidopterans exhibits a certain level of prolonged periodic flooding, the aforementioned tight phenological synchrony between moths and their host-plants, and often a very moderate or well-balanced grazing presence. Moreover, regulated herbivory may safeguard critical riparian ecotones, increasing resilience to severe wildfires.

All known favourable locations for *G. algae* and *F. cicatricella* may lose water for months, having in common the grazing legacy (cattle, horses, and small ruminants) that extends to aquatic environments where rural activities play a role in maintaining riparian biodiversity.

Fig. 7a/b – Recent shot of floodplain meadows in São Martinho do Porto. Three decades ago, the landscape was characterized by more persistent flooding and active grazing, which likely would not have resulted in the wide, monotonous appearance seen today. Currently, land-use promotes drainage via ditches and constant competition between *P. australis* and *S. lacustris*, driven by summer mowing. These macrophytes co-occur, with the latter being seasonally stunted by the dominance of the former. Furthermore, the egg-clutch niches of the target species are removed or severely altered, hence there are no records across this extensive area.

However, during periods of drought and food shortage, livestock can exert disruptive pressure on these ecosystems, even in the absence of chronic overgrazing.

Some examples in the study areas are horse grazing severely consuming stands of *S. tabernaemontani* situated in permanently damp soil, including the dry shoots, or in the same municipality (via Valado dos Frades), cattle may exert a similar impact on *S. lacustris* s.s.; in all cases adding trampling and passage damage, which may also be common to smaller livestock (sheep and goats), as observed in the Óbidos Lagoon (Fig. 6). All ruminants may graze on the green apical halves of the hostplants located peripherally in shallow ditches and banks, particularly as floodwaters recede (a observed phenomenon in the peripheral areas of Paul do Boquilobo).

The egg-clutches of both moths are vulnerable to a range of disturbances, as they remain inside the stem tips for long periods after endophytic laying, from the beginning of the dry season until the following spring eclosion. Eggs remain in dormancy (in Portugal and probably all Mediterranean populations) through much of the summer and following winter (Edelsten, 1907).

In the two identified core populations, *S. lacustris* green shoots annually emerge from the water in late winter, growing rapidly through spring. Later, much like geophytes, they start to senesce as ponds lose water in midsummer, typically almost completely dry in July after fruiting and the egg-laying period. Senescence at this season is advantageous, since it makes the plants less attractive to herbivores on damp ground, especially when forming large monospecific stands (Duncan, 1992). It remains unclear whether this senescence is biologically pre-programmed following peak fruiting in June, or if it is triggered by changes in water parameters just before the pond becomes a damp bed (Clevering, 1998a, b; Coops et al., 1996).

III - Eutrophication and nitrophilous herbs competition:

In theory, the two core populations suggested by this study combine optimal conditions for the interspecific host-moth relationship, despite being vulnerable to significant water level reductions during summer and autumn.

Water depth acts as a limiting factor for *Phragmites australis*, allowing S. lacustris s.l. to maintain a competitive advantage in deeper areas (Coops & van der Velde, 1991). However, when water levels drop, the reed can rapidly displace it through superior rhizomatous expansion (Weisner, 1991), a succession often intensified by eutrophication (Clevering, 1998a). Furthermore, the role of herbivory is a decisive factor; while the absence of large herbivores - following rural abandonment in Portugal (Paiva, 1993) - allows *P. australis* to form dense, impenetrable monospecific stands (Vulink, 2001), moderate grazing can act as a beneficial management tool (Bakker et al., 2013). However, this balance is fragile, as excessive grazing and trampling during dry periods can severely compromise *S. lacustris* (Middleton, 1999). Therefore, as the site of Poça do Vau dries and this plant senesces, livestock (cattle and horses in former times, and now small livestock) often shift their grazing pressure towards nearby helophyte species with later phenologies that remain green and nutritious until the end of the season, such as *Phragmites* (Duncan, 1992; Menard et al., 2002).

In the worst-case scenario non-selective, homogeneous industrial-scale forage harvesting in historical wetlands, which replaced former extensive grazing, has proven adverse, as evidenced by the total absence of both lepidopteran species, even where host-plant stands persist (Fig. 6). The egg clutches are taken away with the forage.

Factors associated with nutrient enrichment may also promote the degradation rate of senescent material (Menéndez et al., 2000), potentially compromising the overwintering eggs of the aforementioned moths. The favourable dynamic equilibrium can be difficult to achieve even when science-based management is promoted. It is crucial to ensure both spatial availability and ecosystem variability, guaranteeing that localized niches remain suitable for *G. algae* and *F. cicatricella*.

IV – Forestry

Fig. 8 - Timber harvesting on the banks of the Lagoa de Óbidos during a flood; March 4, 2026.

Intensive afforestation on the periphery of wetlands and sparse shrublands, areas once characterized by a more stable vegetative balance, inevitably triggers silvicultural runoff and relies on harvesting operations currently deemed aggressive to the ecosystem. This is particularly pronounced along the margins and within the drainage basin of the Lagoa de Óbidos, frequently compounded by agricultural practices.

The core population for *G. algae* and *F. cicatricella* in Poças do Vau is currently threatened by a recent Eucalyptus plantation that already suppressed a portion of the pond bed. As the grove matures, *Eucalyptus* leaf litter is expected to further degrade water quality through excessive organic pollution.

V – Drought and wildfires

Potentially suitable habitats for *G. algae* and *F. cicatricella* are found in natural floodplains and dune depressions along the Beira Litoral coast. However, surveys conducted in 2024 yielded negative results across the region, most notably at Lagoa da Vela, which retains well-recovered stands of host-plants. The absence of these species possibly dates back to October 2017, when the region was devastated by the combined impact of extreme drought and severe wildfires, which presumably affected the insects during their egg stage. Even today, in areas largely devoid of livestock grazing, the landscape still exhibits lingering evidence of fire damage.

VI- Notes on *Globia algae*

The life cycle of this Euro-Siberian Noctuidae has been documented for over two centuries, primarily by researchers from Northern and Central Europe where it thrives in local, patchy populations. However, its ecological dynamics and phenology in South-western Europe remain poorly studied.

All Portuguese records of *Globia algae* come from wetland environments, with dense stands of *Schoenoplectus lacustris* (L.) Palla. Adults can be found flying over water bodies, sometimes deep (70 cm). They can be active in heavy rain, and males especially may come into contact with the water (unharmed) when in a search for mates.

A variability is known from the species, ranging from pale forms to “sooty brown” (South, 1907). In the studied populations, the vast majority of *G. algae* males are quite dark (grey-brown), corresponding to the description of *ab. fumata* Warren (though not always evident in photographs; Fig. 10). A few exceptions display a mosaic pattern blending female coloration with the typical local male dark greyish-brown tones.

Schoenoplectus lacustris has been mentioned as a host-plant by authors including Edelsten (1907), Bergmann (1954), Kintzl (1966), Bretherton et al. (1983), as well as other large helophytes, in latitudes where *G. algae* is described as more widespread and less rare than *Globia sparganii* (Esper, 1790), both co-existing occasionally (Bergmann, 1954). After a single record from Lagoa de Santo André, in 1997 (Corley, 2004), there are no recent records of *G. sparganii* in Portugal, currently being considered an Endangered (EN) species, according to the Red Book of Invertebrates of Portugal (Boieiro et al. 2023).

Fig. 9 – Chromatic polymorphism in G. algae. Upper half: females. Lower half: males (2024).

a) A primary host plant:

In this study, *Schoenoplectus lacustris* (L.) Palla s.s. was identified as the primary host for regional *G. algae*. Contrary to Central and Northern European literature, no life-cycle stages showed a clear affinity for other helophytes, such as *Typha* spp., *Sparganium erectum* L., or *Phragmites australis* (Cav.) Trin ex. Steud, even when in close proximity to *S. lacustris*. The sole exception was *Iris pseudacorus* L.; at Poça do Vau, several larvae in various instars were found on this species, but only in immediate proximity to *S. lacustris* stands (Fig. 10f): young larvae were observed on the leaves, while larger instars were found within the base of the flower stems as reported by Edelsten (1907). Larvae are highly mobile and disperse in marshy environments immediately upon hatching (Fig. 10c), but there were no observetions or signs of egg-laying on *Iris*.

Also, egg-bearing stems that detach from the host-plant may disperse in floodwaters, potentially allowing neonate larvae to colonize suitable peripheral plant stands or even other ponds. However, despite the abundance of *Typha* spp. and *Iris* stands on the periphery of core populations with *S. lacustris* (in Lagoa de Óbidos), larvae are consistently absent from surfaces dominated by other helophytes (described in literature as host-plants) other than *S. lacustris*.

Although larval mobility toward helophyte species is documented elsewhere in Europe (Bretherton et al., 1983), only one internal gallery was detected in *Typha latifolia* L., at the Óbidos Lagoon, located within *S. lacustris* stands. The empty gallery likely belonged to *Nonagria typhae* (Thunberg, 1794), often found on this plant genus in nearby ponds. Consequently, *Iris pseudacorus* remains the only confirmed secondary host plant for *G. algae* in Portugal to date (still highlighting that no egg-laying or dedicated imago patrolling was observed around *I. pseudacorus*).

Occasional resting adults, including those expanding their wings or mating after emerging, found on other plants but close to the primary host, are not considered significant.

b) Breeding season:

In Lagoa de Óbidos (2024–2025), the mating season extends from May to late July, peaking approximately two weeks later than in Paul do Boquilobo and becoming infrequent thereafter. The species is rarely recorded by light trapping or direct observations far from the identified core populations, demonstrating a strong affinity to these. The only instance recorded far from host-plant location occurred repeatedly close to a willow tree covered with abundant aphid honeydew, at Pequena Poça do Vau; however, unlike several *Lenisa geminipuncta* (Haworth, 1809), no adults of *G. algae* were observed feeding.

Both sexes exhibit peak activity at dusk, with males searching among *S. lacustris* stems in flooded or saturated conditions. Mating can occur before total darkness, immediately after females emerge, while they are still soft. Females typically remain just over or close to their exit holes (Fig. 2), therefore mating happens right away, low on the stems, approximately 15–30 cm above the water on intertwined stems.

Post-mating, the female climbs higher and may begin oviposition that same night (Fig. 10a), generally over water, and only dispersing when she is lighter. Many mated females were observed ovipositing during the first half of the night, or later.

Shortly after dark, males conceal themselves within the vegetation – though not at great depth – and the majority remain inactive until dawn, eventually seeking daytime refuge deeper within the dense stands. A few females with large abdomens were observed resting quietly late at night at the breeding sites. This suggests they may have emerged long after dark, when males are no longer receptive, or simply that unmated females do not 'call' (release pheromones) late at night. No late-night matings were recorded. Some of the females appearing to be unmated were subsequently detected in mating pairs the following dusk (confirmed through image analysis several times), in close proximity to their previous locations.

Fig. 10 – Life cycle stages *in situ* from Lagoa de Óbidos (except image "e" - Salir do Porto). From left to right: a) Egg-laying inside the stem (15.vi.2024); b) Egg diapause inside the stems (14.x.2024); c) Recently hatched larva (3.iii.2025); d) First instars on the upper half of the stalks (23.iii.2025); e) Full-grown caterpillar inside the stem (21.v.2024); f) Larva on *Iris pseudacorus* (24.v.2024); g) Movements in search of new stems (20.vi.2025); h) Construction of the pupal chamber with an upward exit hole (22.vi.2024); i) Pupa on a submerged stem (21.v.2024); j) Puparium left in a higher position after emergence (20.vi.2024); l) Opened exit hole (20.vi.2024); m) Mating at dusk almost immediately after female emergence (29.vi.2024), with the female on top.

Observations of ovipositing females demonstrate the function of the double hook-shaped apparatus (Figs. 10a, 11).

Perched on the upper vertical half of a cylindrical *Schoenoplectus* stem, often less than half a centimeter in diameter, sometimes on mature green and more often on younger stems (mid-height), she remains firmly anchored by her legs and positions the tip of her abdomen laterally, engaging the 'hook' which clasps the stem's circumference to initiate an active mechanical incision, exploiting the longitudinal ‘grain’ of the stem (taking advantage of the structural weakness between the epidermal cells, and the stem in *Schoenoplectus* can be notably hard and slippery). She actively creates a slit to lay the eggs inside. This is consistent with what Edelsten (1907) states: “female is provided with special hooks, which enable her to lift the natural folds of the cuticle to deposit the ova”.

The process takes several minutes, repeating the slow process in a downward motion on each selected stem, potentially leaving the female vulnerable to certain bat species. Left behind is a line of minute cracks, also described by Edelsten (1907), each sheltering a variable number of inserted ova. Each site remains slightly moist, likely due to a mucilaginous secretion and/or discharged plant fluids. She gradually changes from stem to stem, increasing the distance each time.

c) Egg stage:

The eggs overwinter inside the stems (fig. 10b), which ideally remain upright and can dry very soon without damaging the eggs within. When the flooding season begins, even if the stalks drop into the water, they remain buoyant for some time due to their internal structure rich in air pockets. Many of these remain trapped above the surface in the tangle of dense stands. Most of the stems remain upright long after drying, sometimes until the next year (even after the floods). Winter temperatures probably help to prevent the material from completely decomposing in humidity before the larvae hatch.

At Poças do Vau, some senescent plant material may become submerged during the cold season. However, in the niches where the species is most abundant, the decayed stems generally do not collapse entirely nor remain underwater for prolonged periods (Figs. 5b, 12a). Furthermore, specific environmental factors must ensure that these stems are not washed away by water currents.

Fig. 11 - Details of the female's ovipositor apparatus in action (opposite side in the last photo). Note: they do not represent the same female.

d) Larval stage:

Neonate larvae are observed in large numbers at Lagoa de Óbidos in early March, remaining active in daylight (consistent with positive phototaxis already reported by Eckstein (1920)). Eclosion was also documented in captivity, with larvae emerging from senescent stalks stored since the previous summer. Larvae are capable of hatching while submerged, subsequently detaching from the stem either underwater or at the surface. First instar larvae are pale brown with a contrasting dark head capsule (Eckstein, 1920; Zilli et al., 2005) and tend to climb and establish themselves within the apical third of young green stems (Fig. 10d). More developed larvae, which are light green with dark marks (Buckler, 1891; Zilli et al., 2005), with "a brown head and a whitish green plate on first ring of the body" (South, 1907), are very prone to change from stem to stem (Eckstein, 1920); (Fig. 10f), frequently observed at night in the water, floating/swimming and moving between obstacles, as well as temporarily submerged clinging to stems while boring into the tissue (making an entry), a phase in which they may be more vulnerable to predation.

Larvae can be found consistently in central and peripheral deep areas of a small pond, but always in standing waterlogged vegetation.

At the core population of Lagoa de Óbidos, they are actually detected in large numbers (100–200 according to reliable evidence of occupation) in late spring, often in water exceeding 70 cm in depth in May–June.

Following the extensive flooding caused by Storm Kristin in March 2026, which merged all the floodplains of the Vau ponds into a single, large, continuous, and deeply inundated water body, small larvae in the subsequent spring, after water levels had receded, hatched and were competing for the few upright plant stems that managed to protrude above the pond surface (fig. 12 a/b).

Fig. 12a/b: Post-Storm Kristin habitat status of the pond from Fig. 5a/b, on 06.iv.2026, with water levels within the seasonal norm. Major threats include allochthonous pollution accumulated during the floods. Population survival is critically dependent on rapid vegetation recovery for larval shelter; however, regrowth appears delayed this year, despite ongoing larval development. This delay, coupled with the turbidity observed after water levels stabilized, suggests that the primary drivers of habitat degradation could be chemical alterations. Currently, larvae are restricted to only two marginal areas of 1 m² each, where high densities of early instars compete for the few dozen available stems. Most plants visible at the pond's periphery are *Scirpoides holoschoenus* (L.) Soják, which do not function as host plants.

e) Pupal stage:

Similar to *F. cicatricella*, the placement of the slightly elongated pupal chamber depends on the pond’s water level at the time of construction. As water levels recede throughout the spring, chambers in different stems are found at varying heights, determined by the water surface rather than the distance from the rhizomes. Likely a defense against non-aquatic predators, the chamber is positioned so the pupa stays below the surface, and the still closed exit hole is excavated in the internal tissue until only a thin, transparent membrane remains, as earlier explained by Edelsten (1907) with pupa head upright (Buckler, 1891; South, 1907). The exit hole is consistently placed at or just above the waterline, and the top of the chamber is blocked by plant fragments just over the exit spot (to indicate the exit). This species was observed pupating in thin stems in which it barely fitted.

In contrast to *Phragmataecia castaneae* (Hübner, 1790), the pupa moves clumsily and only slightly along the chamber. Low mobility was already reported in literature (Edelsten, 1907; Zilli et al., 2005).

In contrast to the larval boring effect, the pupal chamber construction can drastically reduce fluid circulation in the stem, somewhat compromising the structure’s lifespan, or even cause bending if forced; but generally, not showing signs of decay in the short term, nor lead to the moth failing to emerge (the pupal stage is notably brief, lasting from less than one week to two, likely depending on meteorological conditions). Sometimes, especially in shady conditions and if the water level has dropped significantly, the stem can break next to the exit hole (weak point). If it breaks within a sudden late season flood, the pupa may drown if water enters, or fall out and sink. During the pupal stage (nearly the same as flying period), the summer arrives with partial dormancy of the plant (in Lagoa de Óbidos), and many of the oldest healthy stems lose their vitality, gradually turning yellow or brown, camouflaging all traces of impact left by *G. algae*.

f) Predation:

Confirmed predators include the brown rat *Rattus norvegicus* (Berkenhout, 1769) which swims, climbs the vegetation, and takes larvae and pupae if the water level drops too much; also the great tit *Parus major* Linnaeus, 1758, which bores into stems. Possibly also the red swamp crayfish *Procambarus clarkii* (Girard, 1852), as it infests all aquatic systems where this moth is found but the impact is probably insignificant. Interestingly, the low flight pattern of the males - the lowest observed by the author among noctuids, barely skimming the water's surface - appears to render bat predation quite difficult. While the western swamphen *Porphyrio porphyrio* (Linnaeus, 1758) is a potential destroyer of tall helophytes in deep waters and along banks, no significant host plant damage was confirmed at any studied location. Similarly, signs of predation by smaller Rallidae (which Edelsten (1907) reports as serious predators of the species) were observed sparingly in Natural Reserves and more frequently in the large Poça do Vau, though data remains insufficient to determine if they act as a limiting factor.

Observations revealed a few egg laying females exhibiting significant physical compromise and the appearance of having struggled in the water. This suggests high reproductive resilience following accidents such as predator encounters or emergence failures caused by submerged host stalks, or difficulty climbing to a dry perch. Even in ponds with high densities of aquatic predators (dragonfly larvae, crayfish, and frogs), these damaged or even unable to fly individuals appear to achieve sufficient reproductive success.

g) A metapopulation strategy:

Regional observations suggest that *G. algae* is a highly specialized moth adapted to a metapopulation lifestyle, taking advantage of naturally fragmented niches. This strategy allows for high population densities to offset the scarcity of niches with optimal conditions. Provided that host-plants encounter favourable growth conditions, larvae can infest small flooded areas annually with no serious impact on the plant nucleus.

In the two known core populations, the density of mined stems (including empty galleries) can exceed 60–70% without compromising the habitat. Reproductive behaviour further reinforces site fidelity: by depositing an initial batch of eggs at her emergence site, the female ensures the next generation inhabits a proven, viable environment. Furthermore, evidence from captive specimens indicates a lifespan exceeding one week with gradual oviposition, suggesting significant dispersal potential; the species is not restricted to its natal site and may colonize new habitats that may arise. However, while this metapopulation strategy has historically been effective, the resulting isolation of populations now leaves the species increasingly vulnerable to habitat loss and anthropogenic interference.

VII - Notes on *Friedlanderia cicatricella*

The first Portuguese occurrence of this Crambid has finally been confirmed, in the marshlands of Lagoa de Óbidos. Notably, specimens from this location exhibit a broader chromatic range than those from the Paul do Boquilobo Nature Reserve, especially the females.

Fig. 13 - *Schoenoplectus tabernaemontani* (C. C. Gmel.) Palla; well developed, downstream of a runoff through tidal marsh vegetation. Óbidos Lagoon (Óbidos, x.2025).

Males and females are very active at dusk, mating and ovipositing around the host-plants near or over water, rarely straying from waterlogged areas (depths 5–70 cm). They may fly low, come into contact with the water and even rest on it (Fig. 14g). As the night advances, activity of both sexes tends to stop.

Mating occurs from dusk onwards, often just before emerged females expand their wings, generally in low position, but sometimes higher than *Globia algae*.

Eggs are laid inside the healthy stems, not necessarily upstanding or in high position (very variable), and larvae can be found closer to the base of the plants, or more rarely up to the last third (younger larvae). The larvae (Fig. 14b) are somewhat fragile and clumsy outside the host-plant, and they have never been observed naturally outside the plant. As in *Globia algae*, the position of the pupal chambers inside the stems is more determined by the pond's water surface than by the position of the plant's stem base. In observed cases, the pupa is oriented head-up or, in some instances, horizontally.

Although the pupae are quite mobile inside the pupal chamber, utilizing specialized spines along the body (Schütze, 1931), (Zilli et al., 2005), this mobility is not nearly as advanced as that of *Phragmataecia castaneae*. This behaviour appears to be a defense against predators, rather than other cause.

The oviposition, larvae, and pupal stages were documented in dense stands of *S. lacustris*, in part earlier reported by Reutti (1853) and Schütze (1931). At Lagoa de Óbidos (Bom Sucesso), the larva was also found in a well-developed nucleus of *Schoenoplectus tabernaemontani* (C. C. Gmel.) Palla., downstream of a runoff covered with tidal marsh vegetation (Fig. 12), immediately above the tide line, under strong marine influence.

At Paul do Boquilobo, this species can be locally very numerous, far exceeding *Globia algae*.

Fig. 14 – From left to right in descending order: a) Egg-laying in *S. lacustris* (9.vi.2024). b) Larva in *S. lacustris* (23.v.2024). c) Pupa in *S. lacustris* (28.v.2024). d) Puparium in *S. lacustris* (5.vii.2024). e-h) Males. i-l) Resting females (lower pictures). a-c; e; g-m: Óbidos Lagoon. d;f: Paul do Boquilobo Biosphere Reserve. The set of pictures does not highlight the size difference between males and females.

VIII – Threats

Environmental and Ecological Threats:

Reed Expansion - Reed beds reducing open water areas.
Eutrophication and Pollution - Nutrient enrichment from agricultural runoff and high organic loads.
Phenological Mismatch - Changes in plant life cycles that disrupt synchrony with moth colonies.
Litter Degradation - Accelerated decomposition of senescent material, potentially destroying overwintering eggs.

Management and Human Activity Threats:

Industrial Forestry and Agriculture - Eucalyptus plantations (causing organic pollution) and large-scale forage harvesting.
Hydrological Changes - Wetland drainage and failure of dynamical equilibrium conditions.
Rural Exodus - Abandonment of traditional activities and reduction of beneficial extensive grazing.
Localized Pressures - Overgrazing, harvesting for basketry, and wildfires exacerbated by droughts.

Biotic and Genetic Threats:

Invasive and Weed Species - Presence of harmful species like the red swamp crayfish (*Procambarus clarkii*) and nitrophilous weeds that compete with native flora and increase the organic pollutant load.
Herbivory and Trampling - Impact of wild boar (*Sus scrofa*) on seedlings and banks.
Genetic Risks - Introduction of external host-plant genetic material and proliferation of hybrids due to unnatural environmental changes. These can result in host-plant stands with genetics and possibly phenology divergent from the native.
Habitat Fragmentation - Loss of localized niches and lack of space availability for specific breeding sites.

IX – Conservation

The persistence of both *Globia algae* and *Friedlanderia cicatricella* in Portugal appears to be closely associated with the availability of small wetland microhabitats dominated by *Schoenoplectus lacustris* that remain structurally persistent under fluctuating hydrological conditions. In the studied sites, these habitats supported high densities of larvae and breeding adults, suggesting that they function as core population nuclei within a fragmented landscape.

Observations of the life cycle indicate that eggs are deposited inside the stems and remain in diapause for extended periods, including during the dry season and winter. As a result, disturbances that remove or damage senescent stems, such as harvesting, trampling, or vegetation clearance, may directly affect overwintering stages and reduce local recruitment. This highlights the potential sensitivity of these species to small-scale habitat disturbance.

The study also suggests that a balance between hydrological variability and habitat stability is important for maintaining suitable conditions. Temporary flooding, followed by gradual drying, appears to support both host-plant development and larval survival. Similarly, moderate grazing pressure may contribute to maintaining habitat heterogeneity, although excessive grazing during dry periods could negatively impact host-plant structure and reproductive success.

The absence of the target species from apparently suitable habitats indicates that the presence of the host plant alone is not sufficient. This suggests that additional factos, such as phenological synchrony, water quality, and disturbance regimes, may play a key role in determining habitat suitability.

Given the localized nature of the observed populations and their apparent dependence on specific microhabitat conditions, conservation efforts may benefit from focusing on the maintenance of small-scale habitat mosaics. Protecting areas where dense stands of *Schoenoplectus lacustris* coincide with stable hydrological conditions could be particularly important for ensuring long-term population persistence.

Although the present study is based on a limited number of sites, it provides initial evidence that these species may be vulnerable to habitat fragmentation and changes in land use. Further research incorporating quantitative monitoring would be valuable to better assess population trends and refine conservation strategies.

Mitigation strategies should be defined at a local scale and evaluated on a case-by-case basis. The precautionary principle (Carraro & Siniscalco, 1993) should guide wetland management, particularly when enhancing habitat availability or reinforcing host-plant populations. It is recommended to prioritize the protection of autochthonous plant communities and prevent the introduction of external genetic material, while remaining vigilant regarding the proliferation of phenotypic forms or hybrids that may arise from unnatural environmental changes.

Legal Protection and Land Management:

Niche Protection - Establish formal protection and restoration by implementing micro-reserves or long-term local management agreements.
Private Land Agreements - Collaborate with large-scale forage and grazing farms to secure specific micro-reserves in small flooded areas that meet the species' environmental requirements.

Habitat and Resource Regulation:

Harvesting Restrictions - Prohibit or strictly avoid the traditional harvesting of *S. lacustris* (common club-rush) within primary breeding hotspots to maintain habitat structural integrity.
Herbivory Control - Implement rigorous monitoring and mitigation protocols to prevent livestock overgrazing in sensitive ecological zones, utilizing seasonal fencing where necessary.

Ecological Restoration:

Helophyte Recovery - Prioritize the restoration of degraded wetland plant communities with *Schoenoplectus lacustris*, focusing on preserving local genetic resources.
Host-plant Expansion - Target the strategic expansion of the primary larval host-plant into large, high-density stands.

Research and Monitoring:

Applied Research - Promote and expand scientific studies on wetland ecology in Portugal to bridge current knowledge gaps regarding associated biodiversity.
Impact Assessment - Establish long-term monitoring programs to evaluate the success of restoration efforts.

Selection of relevant records

Globia algae (Esper, 1789)

Poça do Vau, Óbidos, 20.v.2024 (handheld flashlight).
Several last instar larvae on *Schoenoplectus lacustris.*

Bouro, Reguendo da Parada (Caldas da Rainha), 21.v.2024 (handheld flashlight).
Last instar larva on *Schoenoplectus lacustris* (daylight observation) .

Poça do Vau, Óbidos, 22.v.2024 (handheld flashlight).
Two females on *Schoenoplectus lacustris* (handheld flashlight).

Poça do Vau, Óbidos, 23.v.2024 (handheld flashlight).
Larva moving on stalk and over water (swimming), within *Schoenoplectus lacustris*.

Poça do Vau, Óbidos, 12.vi.2024 (handheld flashlight).
Mating on *Iris pseudacorus*, on *Schoenoplectus lacustris* with exit hole (female's) at a distance of 1 centimeter.

Poça do Vau, Óbidos, 12.vi.2024 (handheld flashlight).
Mating pair on dry leaves of *Typha* sp. (hiding place?) of a female, probably a virgin photographed in the previous morning on *Schoenoplectus lacustris*.

Poça do Vau, Óbidos, 15.vi.2024 (handheld flashlight).
Female, laying eggs on green *Schoenoplectus lacustris* stalks.

Poça do Vau, Óbidos, 15.vi.2024 (handheld flashlight).
Larva on an I*ris pseudacorus* stalk, in a pond with *Schoenoplectus lacustris*.

Paul do Boquilobo, Azinhaga, 5.vii.2024 (daytime observation).
Pupal chamber and puparia on *Schoenoplectus lacustris*.

Paul do Boquilobo, Azinhaga, 7.vii.2024 (handheld flashlight).
Male on patrol near *Schoenoplectus lacustris*.

Poça do Vau, Óbidos, 25.vii.2024 (handheld flashlight).
Male on *Schoenoplectus lacustris* (the latest record of the species on the West Coast so far).

Lagoas de Santo André, Santiago do Cacém, 10.vii.2024 (handheld flashlight).
Male patrolling the shore with Phragmites australis and *Schoenoplectus lacustris.*

Poça do Vau, Óbidos, 3.iii.2025 (daytime observation).
Neonate larva in *Schoenoplectus lacustris* on immerse litter.

Poça do Vau, Óbidos, 23.iii.2025 (daytime observation)
Small larva inside the tip of the *Schoenoplectus lacustris* stalk.

Friedlanderia cicatricella (Hübner, 1824):

Poça do Vau, Óbidos, 18.v.2024 (handheld flashlight).
Female laying eggs on *Schoenoplectus lacustris*.

Poça do Vau, Óbidos, 23.v.2024.
Male patrolling on *Schoenoplectus lacustris* (handheld flashlight).

Poça do Vau, Óbidos, 23.v.2024 (daylight observation).
Last instar larva on *Schoenoplectus lacustris* (reared afterwards, emerged on 28.vi.2024).

Poça do Vau, Óbidos, 28.v.2024 (handheld flashlight).
Female pupa on *Schoenoplectus lacustris* (reared afterwards, emerged on 8.vi.2024).

Poça do Vau, Óbidos, 18.vi.2024, 21.27 WEST (handheld flashlight).
Mating couple on *Schoenoplectus lacustris*; tender female expanding wings during the process.

Paul do Boquilobo, Azinhaga, 5.vi.2024 (daytime observation and handheld flashlight).
Several imagines of both sexes, larvae, a dead larva, and puparia (daytime observation), on *Schoenoplectus lacustris*.

Bouro, Reguendo da Parada (Caldas da Rainha), 12.vi.2025 (handheld flashlight).
Mating couple on *Schoenoplectus lacustris.*

Poça do Vau, Óbidos, 17.vii.2024 (handheld flashlight).
Male on *Schoenoplectus lacustris* (the latest record of the species on the West Coast).

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