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International Biological Flora: *Loranthus europaeus**

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Abstract

1. This account presents information on all aspects of the biology of *Loranthus europaeus* Jacq. (vernacular names: yellow mistletoe; yellow-berried mistletoe) (synonyms: *Hyphear europaeum* (Jacq.) Danser; *Loranthus dioicus* Stokes; *Viscum guernum* Rchb.) that are relevant to understanding its ecological characteristics and behaviour. The main topics are presented within the standard framework of the *International Biological Flora*: distribution, habitat, communities, responses to biotic factors, responses to environment, structure and physiology, phenology, floral and seed characters, herbivores and disease, history and conservation.
2. *Loranthus europaeus* is a deciduous hemiparasite primarily infesting oaks (*Quercus* spp.), although it can parasitize other deciduous trees. Its haustoria form direct xylem connections with host trees, enabling the uptake of water and minerals. Heavy infestations can reduce host growth and vitality and increase mortality. The plant exhibits high transpiration and low water-use efficiency, which exacerbates host stress, particularly under drought conditions.
3. The species is dioecious, with individual plants bearing either male or female flowers, and its seeds are dispersed by birds, especially thrushes. The fruits are sticky berries that adhere to the branches or trunks of the host. Germination and haustorial development depend on light and physical contact with the host. Distribution is influenced by climate, host availability and dispersal vectors.
4. *Loranthus europaeus* is distributed across southern, central and eastern Europe, with isolated populations in western Asia and western Europe, including the United Kingdom. It prefers sun-exposed positions within the host crown. The species not only plays an important ecological role, supporting biodiversity, but also poses a threat to forest health.
5. Biochemically, it is rich in flavonoids, essential oils and fatty acids with potential medicinal applications. Traditionally used in folk medicine, it is now being studied for its antimicrobial, antioxidant and anti-inflammatory properties.

*Nomenclature of vascular plants follows Kew Plants of the World Online https://powo.science.kew.org/.

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KEYWORDS
ecophysiology, geographical distribution, hemiparasite, host tree species, host–hemiparasite interactions, mistletoe management, pathogens, phenology

Yellow mistletoe. Loranthaceae. *Loranthus europaeus* Jacq. is the only European representative of the otherwise tropical genus *Loranthus* (Watson, 2001). In contrast to *Viscum album* L., which parasitizes the branches of various deciduous and coniferous tree species (Thomas et al., 2023), *L. europaeus* is primarily associated with oak species (*Quercus* spp.), but it can occasionally parasitize other tree species, indicating a somewhat broader host range. *Loranthus europaeus* is a woody, aerial hemiparasite with an endophytic system that provides anchorage and nutrient acquisition, while its exophytic system performs photosynthesis and reproduction, forming a dense, globular crown up to 2 m in diameter (Krasylenko et al., 2019; Kubíček et al., 2018). It is characterized by sympodial dichasium branching, with dark-brown twigs that are circular in cross section, and brittle at the nodes. Leaves are opposite or subopposite, oblong to oblong-ovate (2.5–7 cm long), dark green, simple and pinnately veined, with short petioles (0.2–0.8 cm) (Kubát, 1997; Shavvon et al., 2012). They are amphistomatic with paracytic stomata on both surfaces and have an undifferentiated mesophyll (Andronache et al., 2006; Shavvon et al., 2012). The variation in leaf size and shrub architecture appears to be influenced by host species, light availability and elevation. It lacks functional roots and establishes simple cone-shaped haustoria without epicortical or cortical strands, corresponding to wood-rose types (*Dactylanthus*), which penetrate the host xylem and form longitudinal strands to facilitate water and nutrient uptake (Glatzel et al., 2017; Thoday, 1961). It is a dioecious species, with male flowers arranged in racemes and female flowers in spikes. Each flower has two whorls of four to six free yellowish petals (<10 mm), with the outer whorl interpreted as a reduced calyx and the inner whorl as the corolla (Kubát, 1997; Shavvon et al., 2012). Stamens are inserted on the inner whorl petals; pollen grains are tricolpate with a straight-triangular outline in polar view (Grímsson et al., 2017). Floral morphology suggests insect-mediated pollination, though specific pollinators remain undocumented (Kuijt, 1969). The presence of nectar is likely, but has not been reported.

Fruit a sticky, golden-yellow berry, ovoid to subglobose, 0.9–1.0×0.5–0.6 cm, containing a single seed with a viscin layer that aids adhesion to host branches (Kubát, 1997; Shavvon et al., 2012). The seeds are globose, dark-brown and deeply wrinkled (0.5×0.3 cm). Mature individuals can produce 100–4000 fruits annually, which serve as an important winter food source for frugivorous birds (Margl & Mayer, 1981; Mayer, 1983; Schröpfer et al., 2010). *Loranthus europaeus* and *V. album* L. are the most widespread European hemiparasitic plants, typically colonizing tree crowns and, occasionally, even trunks. In addition, two other mistletoe species occur in Europe: *Arceuthobium oxycedri* (DC.) M. Bieb. and the rare Azorean endemic *Arceuthobium azoricum* Hawksw. & Wiens (Elias et al., 2024; Krasylenko et al., 2017).

Loranthus europaeus is native to southern, central and eastern Europe, with scattered populations in western Asia (e.g. Turkey, Iran, Iraq) (Uotila, 2011–onwards; GBIF, 2023; WFO, 2025). Isolated populations, regarded as non-native, have also been documented in parts of western Europe (Uotila, 2011–onwards; WFO, 2025). In the south-eastern United Kingdom, there is a single record from an individual tree (GBIF, 2023). The species is heliophilous and thermophilous (Bratanova-Doncheva et al., 2005; Eliáš, 1981, 1987), typically found in open oak woodlands and forest edges, from lowlands up to 2130 m a.s.l. (Gebauer et al., 2012; Kubát, 1997; Sayad et al., 2017). It plays a dual ecological role as both a key resource for frugivorous birds and insects and a stressor for host trees, particularly under drought conditions. Its distribution and impact are expected to expand under climate change (Baranowska et al., 2025; Doležal et al., 2016; Saraj et al., 2015).

1 | GEOGRAPHICAL AND ALTITUDINAL DISTRIBUTION

Loranthus europaeus is native to a broad region that encompasses southern, south-eastern, central and eastern Europe, with its distribution extending into parts of western Asia, including Turkey, Iraq and Iran (Uotila, 2011–onwards; GBIF, 2023; WFO, 2025) (Figure 1). Within Europe, the native distribution of *L. europaeus* is mostly found in Austria, the Czech Republic, Hungary, Italy, Romania, Slovakia and Ukraine, with isolated populations, considered to be non-native due to their disjunct distribution and lack of historical continuity with native ranges, in France, the Netherlands and Poland (Uotila, 2011–onwards; GBIF, 2023; WFO, 2025). A single individual tree infested by *L. europaeus* has been documented in the south-eastern United Kingdom (GBIF, 2023). The species has also been recorded in eastern Spain (Navidi et al., 2023) (Figure 1). Some older records from China and Bhutan are likely misidentifications based on a broader historical concept of the species. According to the Global Biodiversity Information Facility (GBIF), the number of recorded observations of *L. europaeus* has increased significantly since 2018, indicating growing interest and improved reporting. Austria (469), Italy (183) and Czechia (178) have the highest number of documented occurrences, followed by Slovakia (97), Hungary (79) and Greece (53).

The distribution of species is shaped by ecological factors such as the availability of susceptible host trees and the presence of seed-dispersing birds, along with broader climatic conditions (Baranowska et al., 2025; Eliáš, 1985). Winter and spring frosts can



FIGURE 1 *Loranthus europaeus* distribution map as recorded by the Global Biodiversity Information Facility (GBIF, 2023). The mostly continuous area of *L. europaeus* occurrence is marked with an orange line. Green points—GPS coordinate derived from the GIBF database; Red names—only country names added to the GIBF database; Blue point—*L. europaeus* occurrence based on the record by Navidi et al. (2023). A red circle covering state names or individual points indicates a non-native *L. europaeus* occurrence according to Uotila (2011–onwards).

limit its distribution in northern regions, while drought stress can increase host susceptibility in southern areas (Doležal et al., 2016; Glatzel et al., 2017; Krasylenko et al., 2019; Mayer, 1982). Elevation also plays a role in the distribution of *L. europaeus*. *Loranthus europaeus* occurs from lowland areas up to 2130 m a.s.l. across its range (Gebauer et al., 2012; Kubát, 1997; Sayad et al., 2017). In the north-western part of its distribution, such as in Czechia, it is typically found at elevations up to 450 m a.s.l. (Gebauer et al., 2012). In Turkey, the species reaches altitudes of about 1450 m a.s.l. (Benabderrahim et al., 2019), while in eastern Spain, populations occur between 520 and 770 m a.s.l. (Navidi et al., 2023). In semi-Mediterranean regions, particularly in Iraq and Iran, it can grow at elevations as high as 2130 m a.s.l. (Sayad et al., 2017). In Iran, the mean number of *L. europaeus* per host tree was nearly double at higher elevations (1751–1800 m a.s.l.) compared to lower ones (1450–1550 m a.s.l.) (Navidi et al., 2016). However, in Croatia, a negative correlation between elevation and mistletoe infestation was observed on *Quercus petraea* (Zebec & Idžojtić, 2006). These contrasting patterns suggest that local climatic and ecological conditions modulate the elevational limits of the species.

2 | HABITAT

2.1 | Climatic and topographical limitations

Loranthus europaeus is a heliophilous and thermophilous species. It predominantly inhabits the upper and marginal parts of oak crowns, where light availability does not limit its physiological activity (Bratanova-Doncheva et al., 2005; Eliáš, 1981) (Figure 2). The species is sensitive to deep shade and is rarely found in dense, closed-canopy forests (Eliáš, 1987; Matula et al., 2015; Millaku et al., 2011; Sayad et al., 2017).

In its north-western range, such as in Czechia, *L. europaeus* typically occurs in areas characterized by dry growing seasons, mean annual temperatures between 7.9°C and 9.7°C and annual precipitation ranging from 460 to 510 mm (Gebauer et al., 2012; Kubát, 1997). In contrast, at the south-eastern edge of its range, particularly in Iraq and Iran, the species is found in semi-Mediterranean climates with annual precipitation between 490 and 835 mm and temperatures ranging from 11°C to 16.5°C (Hosseini & Soleimani, 2022; Mostaghimi et al., 2021; Sayad et al., 2017). In Turkey, *L. europaeus* inhabits humid, mesothermal



FIGURE 2 *Loranthus europaeus* forms dense, spherical to irregular shrubs mostly on small-diameter branches in the upper crown of host trees.

regions with precipitation between 550 and 1500 mm annually and temperatures ranging from −14°C in winter to 38°C in summer (Kumbasli et al., 2011).

Despite this broad distribution, a detailed ecological niche model or environmental suitability analysis for *L. europaeus* is still lacking. It was found that the most important factors influencing the distribution of *L. europaeus* are the (1) presence of its host plant; (2) isothermality, which conveys how much daily temperature varies compared to seasonal changes; and (3) the mean temperature of the wettest quarter or the 3-month period receiving the most precipitation (Baranowska et al., 2025).

2.2 | Substratum

As a hemiparasitic plant, *L. europaeus* obtains water and nutrients from its host by attaching to branches through haustoria. Consequently, its occurrence is indirectly influenced by soil conditions through the distribution and health of its host trees. Across its range, *L. europaeus* is primarily associated with oaks (*Quercus* spp.) (see Section 3), which occupy a wide spectrum of soils, reflecting their ecological adaptations. Across Europe, *Quercus* species typically grow in moderately fertile and well-drained soils ranging from neutral to weakly acidic, although they exhibit broad ecological tolerance (San-Miguel-Ayanz et al., 2016). Common substrates include loamy alluvial soils in lowlands, shallow calcareous soils on slopes and rocky, acid soils in upland regions. Although species such as *Quercus robur* prefer heavier, moist soils and tolerate periodic flooding, others like *Q. petraea* and *Quercus pubescens* thrive on lighter, well-drained substrates (San-Miguel-Ayanz et al., 2016). Extremely waterlogged or highly acidic peat soils generally exclude oaks and, consequently, *L. europaeus*. Based on the Ellenberg indicator values for oak species (Tichý et al., 2023), typical ranges are:

- Light: 5–7 (semi-shade to well-lit sites)
- Temperature: 6–10 (moderately warm to very warm conditions)
- Soil moisture: 4–6 (moderately dry to moist soils)
- Soil reaction: 5–8 (moderately acid to weakly basic)
- Nutrients: 3–5 (low to intermediate fertility)

These values reflect the ecological optimum of oak hosts and indirectly define the habitat suitability of *L. europaeus*.

3 | COMMUNITIES

Loranthus europaeus is most frequently found in deciduous broadleaf forests. These include thermophilous oak-hornbeam forests, mixed oak forests and chestnut forests, where mistletoe can reach high densities (Bratanova-Doncheva et al., 2005; Eliáš, 1987; Gebauer et al., 2012). *Loranthus europaeus* is considered host-specialized, primarily parasitizing oaks (*Quercus* spp.), but it has also been recorded on a variety of other deciduous trees (see Table 1).

Oak species differ markedly in their susceptibility to *L. europaeus* infestation. For example, *Q. robur* is generally less affected than the introduced *Quercus rubra* in Ukraine (Krasylenko et al., 2019). Research from Turkey shows that *Q. petraea* experiences the highest infestation levels, while *Quercus frainetto* is less susceptible and *Quercus cerris* remains completely unaffected (Kumbasli et al., 2011). Comparable trends have been reported in other regions. In the Czech Republic, the infestation rates reached 23% for *Q. pubescens*, 19% for *Quercus virgiliana* and 22% for *Quercus dalechampii*, whereas *Quercus polycarpa* exhibited complete resistance (Gebauer et al., 2012). At this site, some trees hosted as many as 18 mistletoe plants (Urban et al., 2012). In Slovakia, 38% of *Q. cerris* and 24% of *Q. petraea* were infested, and the average abundance across all oak trees was 2.2 mistletoes per tree (range: 0–20 per tree) (Eliáš, 1988). In the same stand, co-occurring *Carpinus betulus* and *Acer campestre* were not affected by the hemiparasite (Eliáš, 1988). In Kosovo, *Q. petraea* showed the highest infestation frequency at 15%, followed by *Q. cerris* at 13% and *Q. frainetto* at 6% (Millaku et al., 2011).

TABLE 1 Tree species recorded to be infested by *Loranthus europaeus*.

Tree species	References
Acer campestre	Kubát (1997)
Betula pendula	Kovaříková and Procházka (2001)
Carpinus betulus	Glatzel (1982); Kubát (1997); Zebec and Idžojtić (2006)
Castanea sativa	Glatzel (1982); Zebec and Idžojtić (2006)
Crataegus monogyna	Millaku et al. (2011)
Fagus sylvatica	Zebec and Idžojtić (2006)
Prunus avium	Glatzel (1982)
Prunus spinosa	Kubát (1997)
Quercus brantii	Hosseini and Soleimani (2022); Navidi et al. (2016); Mostaghimi et al. (2021)
Quercus cerris	Eliáš (1985); Millaku et al. (2011); Zebec and Idžojtić (2006)
Quercus dalechampii	Eliáš (1985, 2002); Gebauer et al. (2012)
Quercus frainetto	Kumbasli et al. (2011); Millaku et al. (2011); Zebec and Idžojtić (2006)
Quercus infectoria	Hosseini and Soleimani (2022); Mostaghimi et al. (2021); Shavvon et al. (2012)
Quercus libani	Mostaghimi et al. (2021); Navidi et al. (2016)
Quercus palustris	Zebec and Idžojtić (2006)
Quercus petraea	Eliáš (2002); Kumbasli et al. (2011); Millaku et al. (2011); Zebec and Idžojtić (2006)
Quercus pubescens	Eliáš (1985); Gebauer et al. (2012); Urban et al. (2012); Zebec and Idžojtić (2006)
Quercus robur	Eliáš (2002); Kubát (1997); Zebec and Idžojtić (2006)
Quercus robur ssp. *pedunculiflora*	Andronache et al. (2006)
Quercus rubra	Eliáš (2002); Kubát (1997); Zebec and Idžojtić (2006)
Quercus velutina	GBIF (2023)
Tilia tomentosa	Kubát (1997)

4 | RESPONSE TO BIOTIC FACTORS

Loranthus europaeus interacts with its host trees at multiple biological levels, including seed germination, haustorial development and nutrient and water extraction. These interactions can significantly influence host physiology and, at a higher level, forest dynamics. The presence of *L. europaeus* on host trees is influenced by factors such as bark thickness, branch diameter and tree age, which affect the success of haustorial establishment. *Loranthus europaeus* infestation was not recorded in younger trees with a stem diameter at a breast height smaller than 16 cm, but it increased steeply from 27 cm onwards (Matula et al., 2015). Similarly, juvenile oak trees with a diameter at breast height below 8 cm show no signs of infestation (Kumbasli et al., 2011). Accordingly, younger forests (under 30 years) show no infestation, while older forests exhibit higher infestation rates (Millaku et al., 2011). Haustorial penetration is easier on younger branches with thin bark, where mechanical resistance is low (Sargent, 1995). Observations indicate that most infestations occur on branches 1–4 cm in diameter, occasionally up to 15 cm, but rarely beyond this threshold (Eliáš, 1988). Older, larger trees are more frequently infested, likely due to increased surface area and



FIGURE 3 Abnormal cambial activity of the host tree, induced by haustorial growth, leads to the formation of host branch hypertrophy.

attractiveness to seed-dispersing birds (Kubíček et al., 2018; Kubov et al., 2020; Matula et al., 2015; Sayad et al., 2017). *Loranthus europaeus* infestation was also observed to depend on host susceptibility (see Section 3). Nevertheless, the underlying anatomical or biochemical basis for this resistance remains to be elucidated. The host's response to infestation triggered abnormal cambial activity, which may lead to bulbous branch swellings at the site of haustorial penetration (Kuijt, 1969) (Figure 3).

Interestingly, although many other tree species grow within vegetation types inhabited by *Loranthus* and share similar environmental conditions, *L. europaeus* has evolved to become highly specialized for oaks. It is hypothesized that long-term coevolution may have resulted in a reduced ability to parasitize other tree species, thus narrowing its host range while enhancing its parasitic efficiency on oaks. Additionally, other tree species might possess physical or chemical defences that inhibit *L. europaeus* from successfully attaching or surviving. Oaks may have a xylem structure that aligns optimally with the mistletoe's haustorial system, facilitating efficient transfer of water and nutrients (Gebauer et al., 2019; Oladi et al., 2025).

5 | RESPONSE TO ENVIRONMENT

5.1 | Gregariousness

Loranthus europaeus exhibits a clumped distribution pattern, often forming dense aggregations on suitable host trees (Eliáš, 1987; Matula et al., 2015; Sayad et al., 2017). This gregariousness is largely driven by the behaviour of seed-dispersing birds, such as the mistletoe thrush (*Turdus viscivorus*), fieldfare (*Turdus pilaris*) and Bohemian waxwing (*Bombycilla garrulus*), which preferentially perch and defecate on prominent branches, leading to localized seed deposition (Mayer, 1983; Cramp & Perrins, 1994; Schröpfer et al., 2010). Then, the infestation often spreads centrifugally from a primary host to neighbouring trees (Eliáš, 1987; Matula et al., 2015). In general, older and larger trees are more frequently infested, likely due to increased surface area and attractiveness to seed-dispersing birds (Kubíček et al., 2018; Kubov et al., 2020; Matula et al., 2015; Sayad et al., 2017).

5.2 | Performance in various habitats

From a habitat perspective, *L. europaeus* is most successful in dry, thermophilous oak forests, but it can also persist in more humid or montane habitats if host trees are present (Baranowska et al., 2025; Eliáš, 1981; Kumbasli et al., 2011). Nevertheless, in moist, nutrient-rich environments, host trees grow vigorously and can shade out mistletoe, reducing its performance (Glatzel & Geils, 2009). The distribution of *L. europaeus* success depends not only on host presence but also on environmental factors, particularly temperature, which emerges as the most influential atmospheric variable shaping its distribution (Baranowska et al., 2025). Elevation also plays a role, though its effect is context dependent and interacts with other site conditions (see Section 2.1).

Within individual stands, light availability strongly determines mistletoe colonization patterns. *Loranthus europaeus* predominantly colonizes the upper and peripheral parts of tree crowns, where light availability supports its photosynthetic activity (Bratanova-Doncheva et al., 2005). In stands with high tree stand density—defined as more than 90% of the area being occupied by tree canopy—the establishment of *L. europaeus* is rare, and individuals occur only sporadically at crown tops, typically limited to one or two individuals per tree (Bratanova-Doncheva et al., 2005). Conversely, in more open stands with canopy coverage below 70%, the infestation intensity increases dramatically, with infected trees hosting 10–15 individuals distributed throughout the crown (Bratanova-Doncheva et al., 2005).



FIGURE 4 Large *Loranthus europaeus* shrub situated on the top of *Quercus petraea* tree with a diameter of 200 cm.

Morphologically, *L. europaeus* shrubs typically reach up to 80 cm in diameter (Eliáš, 1983; Kubát, 1997; Zebec & Idžojtić, 2006). Under optimal conditions, an individual shrub can grow up to 200 cm in diameter (Kubíček et al., 2018) (Figure 4). A single *L. europaeus* shrub with an 80-cm diameter can develop a leaf area of up to 1.23 m^2 (Eliáš, 1983). In heavily infested forest stands, the total leaf surface area may reach 7050 $m^2 ha^{-1}$, with a corresponding dry leaf biomass of approximately 800 $kg ha^{-1}$ (Glatzel, 1983). In less dense infestations, leaf dry matter is around 46 $kg ha^{-1}$ (Eliáš, 1988). The leaf mass per area of *L. europaeus* ranges from 52 to 130 $g m^{-2}$ (Eliáš, 1983; Gebauer et al., 2012; Mostaghimi et al., 2021; Schulze et al., 1984) and increases as the vegetation season advances (Gebauer et al., 2012). Fruit biomass can constitute up to 10% of the total dry matter (Eliáš, 1983), with fruit counts ranging from 100 to 4000 per shrub (Petrlík, 1982, in Buchleitner & Krapfenbauer, 1986). Horizontal growth rates of haustoria can reach up to 1 cm per year (Gebauer, unpublished). The length of the haustorium of an 11-year-old *L. europaeus* was 11 cm (Figure 10).

The presence of *L. europaeus* can influence forest community structure by reducing the vitality and longevity of its hosts. Severe infestations lead to reduced growth, increased susceptibility to secondary stressors and eventual mortality of host individuals, potentially altering canopy composition and dynamics (Glatzel, 1983; Luminita & Ion, 2020; Mostaghimi et al., 2021; Schulze et al., 1984; Urban et al., 2012). In sessile oak, for example, infested individuals exhibit significantly reduced radial growth, with stem increment approximately 34% lower compared to non-infested trees (Kubov et al., 2020). Similar declines have been documented in *Castanea sativa*, where high parasite loads caused pronounced reductions in diameter growth (Bratanova-Doncheva et al., 2005). Mechanistically, the hemiparasite's persistently high transpiration rates depress host water potentials towards critical hydraulic thresholds and restrict carbon assimilation, thereby intensifying long-term growth suppression and predisposing trees to progressive dieback (Schulze et al., 1984; Urban et al., 2012) (see Section 6.5). At the stand scale, such physiological strain manifests as elevated mortality rates among infested trees (Naseri et al., 2011; Sayad et al., 2017). Under drought or additional environmental stressors, the combined effects of hydraulic strain and carbon limitation accelerate branch end-death and crown deterioration, ultimately increasing the likelihood of host tree mortality (Doležal et al., 2016; Eliáš, 1988).

While often viewed as a forest pest, *L. europaeus* also plays a positive ecological role. Crown deterioration in the host tree can promote the growth of light-demanding herbaceous and shrub species, potentially increasing plant diversity in the lower strata. In Australia, mistletoe-induced crown dieback creates microhabitats for cavity-nesting birds and insects, thereby enhancing structural complexity and contributing to overall biodiversity (Watson, 2001). Furthermore, its fruits serve as an essential winter food source for frugivorous birds, such as thrushes, which in turn facilitate seed dispersal (Cramp & Perrins, 1994; Watson, 2001). The floral morphology of *L. europaeus* suggests an entomophilous pollination strategy, although anemophily cannot be entirely ruled out. Related mistletoe species are frequently visited by bees, flies and other small insects (Thomas et al., 2023), indicating that *L. europaeus* may exhibit similar interactions. This assumption is further supported by the detection of its pollen grains in honey samples (Sabo et al., 2011). Nevertheless, targeted field studies are needed to determine the identity and diversity of its pollinators. Despite the species' contribution to complex trophic networks, detailed phytosociological investigations of vegetation communities associated with mistletoe remain scarce, leaving significant gaps in understanding its ecological role within forest ecosystems.

5.3 | Effect of frost, drought, fire, etc.

Loranthus europaeus is sensitive to environmental extremes. Rejmánek (1969) identified the average number of frost days per year as a key factor that limits the presence of *L. europaeus*. Specifically, areas experiencing more than 110 frost days annually tend to restrict its spread. Frost can also damage both the mistletoe and its host, particularly in the early spring when tissues are vulnerable (Eliáš, 2007). Leaf shedding in autumn is believed to be a response to interrupted water supply in the host xylem after frost (Glatzel et al., 2017).



FIGURE 5 *Loranthus europaeus* forms a shrub, which has a sympodial dichasium branching pattern. Twigs are dark brown and fragile at the nodes (indicated by white arrows) (photo M. Svátek).

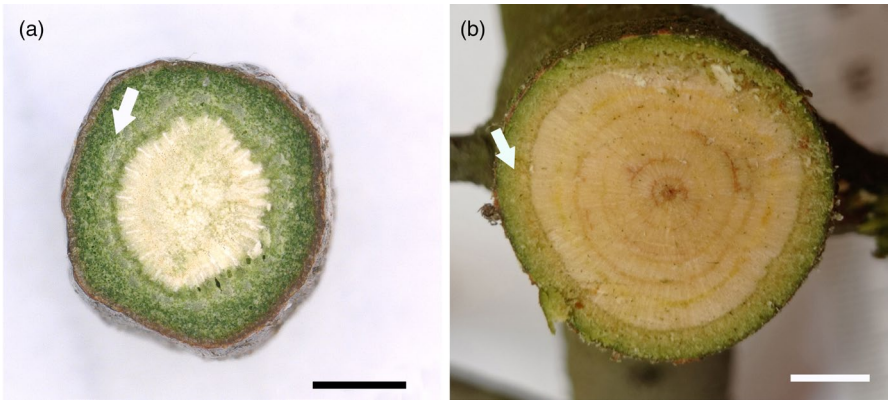


FIGURE 6 (a) Cross section of 1-year old *Loranthus europaeus* twig. The primary cork and phloem cells are coloured in green (white arrow), which indicates the presence of chlorophyll and thus the photosynthetic function of twigs. Bar = 1 mm. (b) Cross section of 6-year-old stem of *L. europaeus* . Tree rings formed by cambium are clearly visible. The central part rarely contains parenchymatous pith. The phloem cells are still photosynthetically active (white arrow, green colour). Bar = 1 cm.

During drought conditions, *L. europaeus* maintains a more negative water potential than its host, enabling it to extract water even under stress (Glatzel, 1983). This further intensifies drought stress in host trees, leading to earlier stomatal closure and reduced carbon assimilation (Glatzel, 1983; Plichta et al., 2013; Urban et al., 2012).

6 | STRUCTURE AND PHYSIOLOGY

6.1 | Morphology

Loranthus europaeus is a deciduous hemiparasitic species with a sympodial dichasium branching pattern (Figure 5). Twigs are dark brown, circular in cross section and fragile at the nodes (Kubát, 1997) (Figure 5). The stem exhibits secondary growth with a complete cambial ring and periderm (Figure 6). Primary cork and phloem tissues are photosynthetically active, containing chloroplasts (Shavvon et al., 2012) (Figure 6).

Leaves are opposite or subopposite, oblong to oblong-ovate (2.5–7 cm long), simple and pinnately veined with short petioles (0.2–0.8 cm) (Kubát, 1997; Shavvon et al., 2012) (Figure 7). They are amphistomatic, with paracytic stomata on both surfaces (Shavvon et al., 2012) (Figure 8). The stomatal density is approximately 70 stomata per mm^2 and shows little difference between the abaxial and adaxial leaf surfaces (Gebauer, unpublished data). The mesophyll is typically undifferentiated, though some studies report palisade and spongy layers (Andronache et al., 2006). Petioles are elliptic in cross section and contain a central vascular bundle (Figure 9). The leaves persist for one growing season and fall in autumn.

Loranthus europaeus lacks functional roots and obtains water and nutrients via haustoria (Buchleitner, 1983; Kuijt & Toth, 1976; Thoday, 1961) (Figure 10). The haustorium penetrates the cambium of the host and spreads along the wood, forming distinctive longitudinal strands below the bark (Thoday, 1961). At the interface, the mistletoe vessels fuse with those of the host, creating a highly conductive junction that allows efficient water transfer (Glatzel et al., 2017). There is no phloem continuity; phloem elements within the haustorium terminate well before reaching the host interface (Kuijt, 1969). The initial haustorium develops from the seedling's holdfast disc, which penetrates the bark and cambial zone shortly after germination (Kuijt, 1969; Thoday, 1961). Unlike *Viscum*, which develops cortical strands and sinkers, *L. europaeus* forms a single primary haustorium that spreads beneath the cambium and then differentiates into longitudinal strands along the host wood (Thoday, 1961). These strands are embedded in the host wood, bulge into the phloem and grow synchronously with host xylem (Glatzel et al., 2017; Thoday, 1961) (Figure 10). Over time, older strands can become overgrown by host wood, but they maintain contact with the outer tissues through radial shafts (Thoday, 1961). The growth of the strands is not continuous but occurs in phases, possibly regulated by enzymes that soften host tissues ahead of the growing tip (Thoday, 1961). The relationship between *L. europaeus* and its host is highly flexible, producing a wide range of attachment forms, from small, short-lived connections to large, complex structures, depending on the relative vigour of host and parasite (Thoday, 1961).

Loranthus europaeus has a xylem structure similar to that of its oak host, which is ring-porous (Glatzel et al., 2017). Vessel diameters in petioles and twigs average 12 µm, with lumen areas of 88–100 µm^2, which were lower compared to its host *Q. pubescens* (Gebauer et al., 2019). Despite narrower conduits, the high vessel density allows *L. europaeus* to maintain a xylem-specific hydraulic conductivity comparable to that of its host (Gebauer et al., 2019).

6.2 | Mycorrhiza

There is no evidence of mycorrhizal associations in *L. europaeus*, which lacks functional roots and obtains water and nutrients through haustorial connections to the host xylem. Nevertheless, it was observed that mistletoe *Phoradendron juniperinum* Engelm significantly



FIGURE 7 *Loranthus europaeus* leaves are dark green, oblong or oblong-ovate, longer than wider, opposite, simple, pinnately veined and with short petioles. The maturing fruits are visible (white arrow).

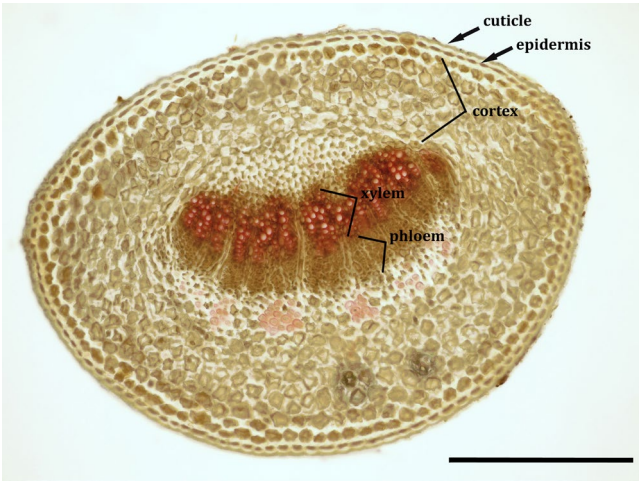


FIGURE 9 *Loranthus europaeus* petiole cross section has a mostly elliptic shape. Phloroglucinol with hydrochloric acid staining highlights lignin distribution: Dark red in xylem, pink in fibres. Bar = 0.5 mm.

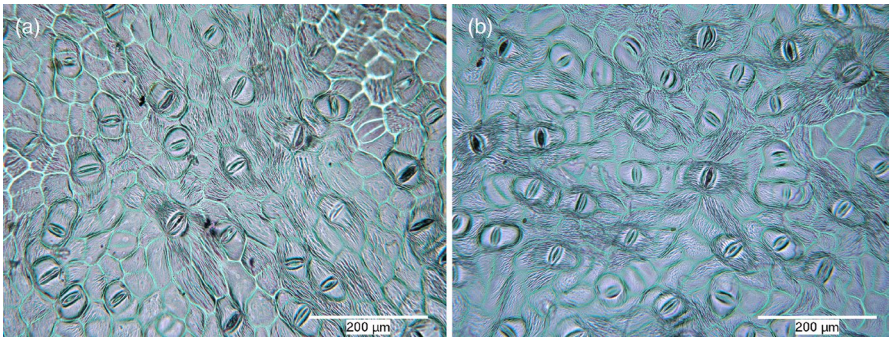


FIGURE 8 *Loranthus europaeus* stomata (white arrows) are irregularly arranged, of paracytic type (pairs of surrounding cells aligned parallel to stomata guard cells; black arrows), and present in both epidermises: (a) abaxial leaf epidermis; (b) adaxial leaf epidermis. Bar = 0.2 mm.

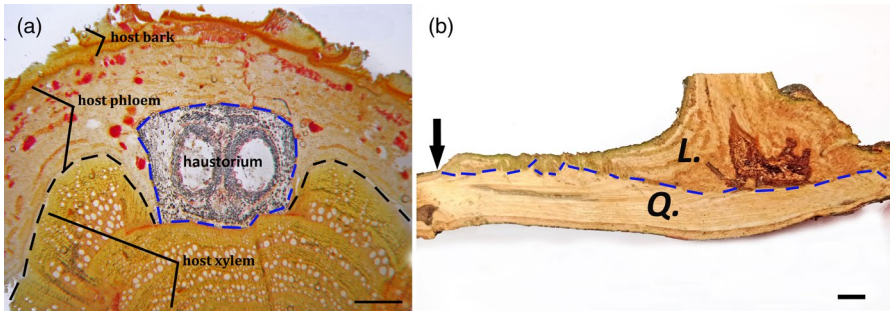


FIGURE 10 (a) Cross section of *Q. pubescens* branch infested by *Loranthus europaeus* haustorium. The cross section was stained with phloroglucinol and hydrochloric acid to reveal lignin (red) together with Lugol's solution to indicate the presence of starch (black). Cambium zone (black dashed line); host–haustorium interface (blue dashed line). Bar = 0.5 mm. (b) Longitudinal cross section of *Q. pubescens* branch (*Q.*) infested by *L. europaeus* (*L.*). The end of the haustorium is marked by a black arrow. Host–haustorium interface (blue dashed line). Bar = 1 cm.

reduced mycorrhizal colonization in infested *Juniperus monosperma* Engelm hosts (Gehring & Whitham, 1992). At a stressful site, heavily infested male trees had 27% fewer mycorrhizae, while female trees showed a 38% reduction compared to lightly infested individuals (Gehring & Whitham, 1992). Similarly, infestation by dwarf mistletoe (*Arceuthobium*) reduces ectomycorrhizal fungal richness and diversity in lodgepole pine and shifts community composition towards taxa with potentially lower carbon demands (Cullings et al., 2005). Conversely, in pinyon pine, ectomycorrhizal colonization was positively correlated with the severity of the infestation by *Arceuthobium divaricatum* Engelm (Mueller & Gehring, 2006). The effect of *L. europaeus* on the host mycorrhizal abundance and diversity is not known.

6.3 | Perennation: Reproduction

Loranthus europaeus reproduces sexually via unisexual flowers and bird-dispersed seeds. Germination occurs directly on the host branches, where the seedling forms a haustorium that establishes connection to host xylem. The generation time from seed to fruiting adult can be as short as 3 years (Kubíček & Martinková, 2010). The life cycle of *L. europaeus* is shorter compared to that of host trees; the oldest living hemiparasite that grows on *Q. petraea* was observed to be 24 years old (Urban et al., 2012). The upper age of *L. europaeus* growing on chestnuts reached 15 years (Bratanova-Doncheva et al., 2005). These findings indicate that *L. europaeus* individuals are typically 15–24 years old.

Secondary shoots can arise from the basal region of the haustorium, but unlike *Viscum*, the longitudinal strands themselves do not typically produce epicortical runners or additional shoots along their length (Thoday, 1961).

6.4 | Chromosomes

Chromosome counts for most of the family Loranthaceae were made by Barlow and Wiens (1971, 1973) and Wiens (1975). It was found that the family Loranthaceae has a basic chromosome number that varies by subtribe. The primary chromosome number (2n) for the family Loranthaceae is 24 (Barlow & Wiens, 1971, 1973). Polyploidy has been found in only about 1% of the species studied and appears to be of little evolutionary significance in the family (Kuijt, 1969). *Loranthus europaeus* belongs to the subtribe Loranthinae, which has a chromosome number (2n) of 18 (Šmarda et al., 2019), indicating progressive dysploidy reduction from the primary chromosome number (Barlow & Wiens, 1971, 1973). The genome size (2C) of *L. europaeus* is approximately 16,830 Mbp, and the guanine–cytosine (GC) content in nuclear DNA is 45.8% (Šmarda et al., 2019).

6.5 | Physiological data

Mistletoes, as perennial flowering plants and aerial hemiparasites, face several physiological challenges (Glatzel & Geils, 2009). To grow and reproduce, mistletoes must compete for the host's water, avoid mineral deficiencies, tolerate differences in host xylem sap chemistry and flower and seed within the host canopy (Glatzel & Geils, 2009; Kuijt, 1969).

Transpiration rates in *L. europaeus* are exceptionally high, three to five times greater than in host trees, ranging from 5 to 10 mmol m^{-2} s^{-1} (Eliáš & Huzulák, 1978; Glatzel, 1983; Luminita & Ion, 2020; Schulze et al., 1984; Urban et al., 2012). Daily water loss can reach 12.9 kg m^{-2}, with seasonal totals exceeding 1200 kg m^{-2} (Urban et al., 2012). High transpiration was proposed to be essential for sufficient nutrient uptake (Glatzel, 1983; Schulze et al., 1984). Despite the high transpiration rates, *L. europaeus* exhibits some degree of stomatal control and the stomatal conductance in *L. europaeus* changes in response to environmental factors such as light, humidity and vapour pressure deficit (Glatzel, 1983; Urban et al., 2012).

Mistletoe maintains a more negative water potential than its host (up to −3.9 MPa), enabling water extraction even during drought (Glatzel, 1983). The water potential gradient between parasite and host can reach 1.5 MPa (Kubov et al., 2020; Schulze et al., 1984; Urban et al., 2012). Osmotic adjustment is achieved through accumulation of potassium, magnesium and sugar alcohols (Press et al., 1990).

Despite its hemiparasitic lifestyle, *L. europaeus* exhibits photosynthetic rates comparable to autotrophic species, ranging from 2 to 12.2 μmol CO_2 m^{-2} s^{-1} (Kubov et al., 2020; Luminita & Ion, 2020). Chlorophyll *a* and *b* concentrations per leaf area ranged 0.6–0.64 and 0.17–0.24 g m^{-2}, respectively (Eliáš, 1988). Photosynthesis also occurs in green twigs, though at lower chlorophyll concentrations (Bampali et al., 2024) (Figure 5). Respiration rates are high (up to 7.5 μmol m^{-2} s^{-1}), indicating substantial carbon expenditure for maintenance and growth (Luminita & Ion, 2020). Mistletoe exhibits partial heterotrophy, obtaining between 20% and 60% of its carbon from host xylem sap (Mostaghimi et al., 2021). The extent of heterotrophic carbon gain by *L. europaeus* varies with host species: approximately 60% in *Quercus infectoria*, 39% in *Quercus brantii* and 23% in *Quercus libani* (Mostaghimi et al., 2021).

Intrinsic water use efficiency (WUEi) is low in *L. europaeus*, approximately four times lower than in non-infested oaks (Kubov et al., 2020). This reflects a strategy to maximize nutrient uptake at the expense of water conservation. Infested trees also exhibit reduced WUEi, which contributes to increased drought stress and reduced growth (Kubov et al., 2020).

Loranthus europaeus accumulates high concentrations of mineral nutrients, often exceeding those in host tissues. For example, the potassium content in leaves can be up to 11 times higher than in the host (Gebauer et al., 2012). However, for leaf nitrogen, the ratio between *L. europaeus* and its host ranged from 0.66 to 1.56 (Gebauer et al., 2012; Glatzel, 1983; Nicoloff, 1923). It has been suggested that elevated transpiration rates in *L. europaeus* may be necessary for mistletoe to acquire sufficient nitrogen from the host xylem to support growth (N-parasitism) (Schulze et al., 1984). The nitrogen content also varies seasonally and by host species, with leaf N ranging from 14 to 22 g kg^{-1} and twig N around 15 g kg^{-1} (Gebauer et al., 2012; Glatzel, 1983; Kubov et al., 2020). The concentrations of phosphorus, calcium, sulphur and magnesium also vary seasonally (Gebauer et al., 2012, 2018; Glatzel, 1983; Kubov et al., 2020) (Table 2).

TABLE 2 Mineral nutrient contents of leaves and twigs of *Loranthus europaeus* from different sources. Due to observed mineral content variation during the vegetation season, only the summer period was considered.

Nutrient	Sample	Nutrient content (g kg^{-1})		
N	Leaf	22[a]	19[b]	14[d]
	Twig		15[b]	
K	Leaf	32[a]	29[b]	2.2[d]
	Twig		12[b]	
Ca	Leaf	23[a]	21[b]	2.4[d]
	Twig		4.0[b]	
P	Leaf	2.0[a]	1.2[c]	35[d]
	Twig	2.0[c]		
S	Leaf	1.5[c]		
	Twig	1.0[c]		
Mg	Leaf	3.4[c]	12[d]	
	Twig	2.1[c]		

[a]Glatzel (1983).
[b]Gebauer et al. (2012).
[c]Gebauer et al. (2018).
[d]Kubov et al. (2020).

6.6 | Biochemical data

Loranthus europaeus contains a wide range of bioactive compounds, including flavonoids (quercetin, rutin, epicatechin), phenolic acids, alkaloids, terpenes and essential oils (Aidy et al., 2022; Al-Fartosy & Al-Rikaby, 2007; Bampali et al., 2024; Hamiad et al., 2013; Harvala et al., 1984; Nuaman, 2012; Sharquie et al., 2016). It was observed that the amino acid composition of *L. europaeus* varies significantly according to the geographical location. For example, seeds of *L. europaeus* grown in Iran have high levels of aspartic acid, serine, alanine, proline and tyrosine, with aspartic acid about 177% higher than in Turkey and 340% higher than in Iraq, and tyrosine 51% higher than Turkey and 18% higher than Iraq (Ali et al., 2023). In contrast, samples from Iraq are rich in glutamic acid, asparagine, glycine and glutamine, with asparagine about 45% higher than Turkey and 30% higher than Iran, while glutamine is 99% higher than Turkey and 46% higher than Iran (Ali et al., 2023). Turkey shows the highest cysteine content, about 7% higher than Iran and 86% higher than Iraq (Ali et al., 2023). The total phenolic and flavonoid content also vary between different organs of *L. europaeus* (Benabderrahim et al., 2019; Çömlekçioğlu et al., 2024). The twig extracts of *L. europaeus* were rich in fatty acids including unsaturated fatty acids (Bampali et al., 2024; Chiarlo & Cajelli, 1965). Apart from being intrinsic antioxidants, unsaturated fatty acids have emerged as general defenders against abiotic stresses such as cold, heat, drought and salt (He & Ding, 2020).

7 | PHENOLOGY

Loranthus europaeus is a deciduous hemiparasitic species with a seasonal life cycle closely synchronized with that of its host trees (Glatzel et al., 2017) (Figure 11). Flowering occurs in late spring to early summer, typically from May to early June (Krasylenko et al., 2019; Zebec & Idžojtić, 2006) (Figure 12). Following successful pollination, fruits develop over the summer and ripen in the late autumn. By September, immature green fruits are visible and ripen to a golden-yellow colour by late autumn (Figure 12). Fruit maturation typically occurs between October and November, with fruits persisting on the plant until winter. This extended fruiting period ensures the availability of food for frugivorous birds during times of scarcity.

Leaf development is slow; the leaf expansion typically starts at the beginning/mid-April and reached its full size by mid/end of August (i.e. more than 4 months are needed to reach full expansion) (Gebauer et al., 2012). Leaves are shed in autumn, likely as a



FIGURE 11 The synchronous flushing of new foliage in both the host and the mistletoe ensures that *Loranthus europaeus* can acquire sufficient nutrients.



FIGURE 12 (a) *Loranthus europaeus* developing fruit on the 1st of June; (b) fruit development on the 20th of September; (c) fruit ripening on the 10th of November. Locality: Czech Republic.

response to reduced water availability in the host xylem after frost events (Glatzel et al., 2017).

8 | FLORAL AND SEED CHARACTERS

8.1 | Floral biology

Loranthus europaeus is a dioecious species, with male and female flowers borne on separate individuals. Male flowers are arranged in terminal racemes, while female flowers occur in terminal, loose spikes (Zebec & Idžojtić, 2006). The corolla consists of two whorls of four to six free petals, each shorter than 10 mm (Kubát, 1997). The outer whorl is interpreted as the calyx, which is reduced, and the inner whorl as the corolla, typically yellow or yellow-green in colour (Kubát, 1997; Shavvon et al., 2012). Stamens are inserted on the petals of the inner whorl (Shavvon et al., 2012), and pollen grains are tricolpate with a straight-triangular outline in polar view (Grímsson et al., 2017). The ovary is inferior, and the style is filamentous, ending in a head-shaped stigma (Nickrent et al., 2010).

Loranthus europaeus is generally considered entomophilous, relying on insects for pollination (Kuijt, 1969). Although specific pollinator taxa have not been recorded for this species, related mistletoe species are commonly visited by bees, flies and other small insects (Thomas et al., 2023). Nevertheless, the possibility of anemophily in *L. europaeus* cannot be excluded.

A notable feature of the species is the skewed sex ratio: the female-to-male flower ratio was found to be 0.26, significantly lower than the expected 0.5 (Eliáš, 1983), suggesting a male-biased population structure.

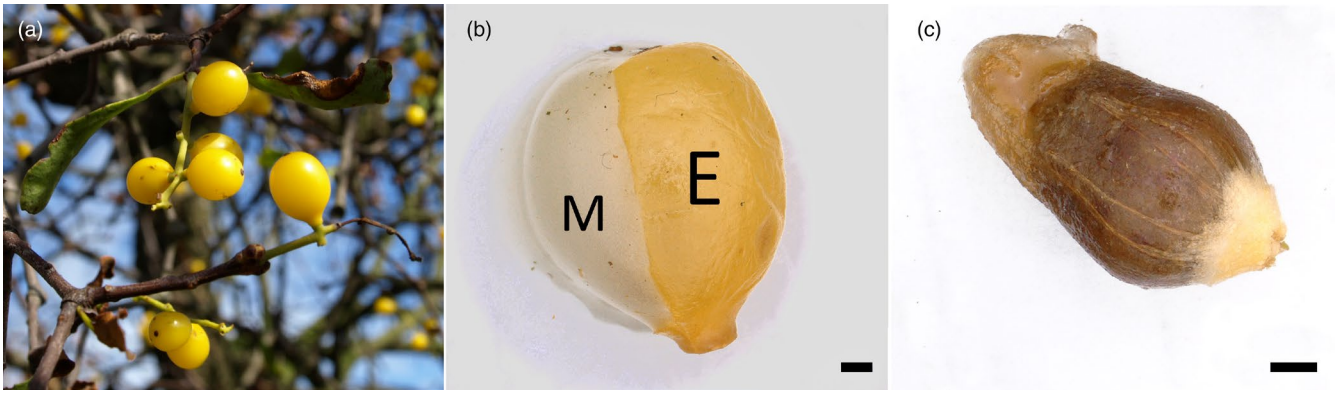


FIGURE 13 (a) *Loranthus europaeus* fruit is a berry, which has a golden-yellow epicarp; (b) the mesocarp (M) of *L. europaeus* fruit has a mucilaginous tissue called the viscin layer; E—epicarp; (c) *L. europaeus* seeds are globose, dark brown and deeply wrinkled. Bar = 1 mm.



FIGURE 14 The viscin layer of the fruit helps the *Loranthus europaeus* seed attach to the host branch.

8.2 | Hybrids

No natural hybrids involving *L. europaeus* have been reported. Although the genus *Loranthus* includes several species in Asia, *L. europaeus* is the only representative in Europe, and hybridization with other species is unlikely under natural conditions.

8.3 | Seed production and dispersal

The fruit is a golden-yellow berry with a smooth surface, containing a single seed (Shavvon et al., 2012; Zebec & Idžojtić, 2006) (Figure 13). It is ovoid to subglobose, measuring approximately 0.9–1.0 × 0.5–0.6 cm (Kubát, 1997; Shavvon et al., 2012). The mesocarp contains a mucilaginous viscin layer that remains sticky even after drying, aiding in seed adhesion to host branches (Calder & Bernhardt, 1983) (Figure 14). The seeds are globose, dark brown, deeply wrinkled and measure 0.5 × 0.3 cm (Shavvon et al., 2012) (Figure 13c). Seeds are produced every year and are significant carbon sinks, accounting for up to 10% of total mistletoe biomass (Eliáš, 1983) (Figure 15). Mature individuals can produce between 100 and 4000 fruits per year (Petrlik, 1982 in Buchleitner & Krapfenbauer, 1986).

Seed dispersal is mediated primarily by frugivorous birds (Margl & Mayer, 1981; Mayer, 1983; Cramp & Perrins, 1994; Konvička et al., 2008; Schröpfer et al., 2010) (Table 3). These birds consume the fruits and deposit the seeds on branches via droppings or wiping them off their beaks. Passage through the digestive tract is not essential for germination (Calder & Bernhardt, 1983), and seeds can germinate successfully even without bird ingestion.

8.4 | Viability of seeds: Germination

Germination begins shortly after seed deposition, typically in late winter or early spring. The cotyledons elongate and orient towards the host surface, guided by gravity or light signal (Calder & Bernhardt, 1983). Upon contact, an attachment disc forms, leading to haustorial penetration and establishment of a xylem-to-xylem connection (Calder & Bernhardt, 1983). This early seedling stage is highly vulnerable to desiccation and predation (Calder & Bernhardt, 1983). It was proposed that the development of the haustorium requires a specific chemical or mechanical signal from the host, distinct from those that stimulate germination (Press et al., 1990), but these are still unknown. Hence, aspects of seed germination, seedling establishment and growth of *L. europaeus* are still poorly understood.

8.5 | Seedling morphology

The seedlings consist of hypocotyl and cotyledons, with the haustorium forming shortly after germination. Seedlings are vulnerable to desiccation and predation during early development, and successful establishment depends on suitable host branch characteristics,



FIGURE 15 *Loranthus europaeus* produces many fruits each year, which represent an important carbon sink. Photograph by Martin Svátek.

TABLE 3 Bird species associated with the consumption of *Loranthus europaeus* fruits.

Bird species	Status	References
Bombycilla garrulus	Observed	Mayer (1983); Konvička et al. (2008); Schröpfer et al. (2010)
Turdus viscivorus	Observed	Margl and Mayer (1981); Mayer (1983); Béres and Ardelean (2002); Konvička et al. (2008)
Turdus pilaris	Observed	Mayer (1983); Béres and Ardelean (2002); Konvička et al. (2008)
Garrulus glandarius	Indicated	Cramp and Perrins (1994)
Sturnus vulgaris	Indicated	Mayer (1983)
Turdus iliacus	Indicated	Cramp and Perrins (1994); Zebec and Idžojtić (2006)

Note: Species categorized as 'observed' were directly documented feeding on the fruits in field studies, while those marked as 'indicated' were mentioned in literature as potential consumers.

such as bark thickness (Kubíček et al., 2018; Kubov et al., 2020; Sargent, 1995) (Figure 16).

9 | HERBIVORY AND DISEASE

9.1 | Animal feeders or parasites

A total of 11 insect species have been recorded parasitizing *L. europaeus* between (Ellis, 2001–2025) (Table 4). These species represent a diverse range of taxonomic groups and parasitic modes, affecting various plant organs. Hemiptera is the most represented order, with six species across three subgroups: Coccoidea, Sternorrhyncha and Heteroptera (Table 4). Notably, *Koroneaspis aegylopos* and *Chionaspis salicis* (Diaspididae) are scale insects, while *Cacopsylla visci* induces galls on leaves. Aphids (*Aphis fabae fabae*) and mirid bugs (*Pinalitus coccineus*, *Pinalitus viscicola*) are free-living leaf feeders. Coleoptera includes three stem-boring beetles: *Agrilus kubani*, *Agrilus roscidus* (Buprestidae) and *Tetrops praeustus* (Cerambycidae), which may contribute to structural damage to the host plant (Table 4). Lepidoptera is represented by two species: *Acalypris loranthella*, a leaf miner (Nepticulidae), and *Synanthedon loranthi*, a stem borer (Sesiidae).

The potential of insects to be used in the biological control of *Loranthus* has been suggested, particularly in the context of forest management, where mistletoe infestation can negatively impact host tree health (Mushtaque & Baloch, 1979).

9.2 | Plant parasites

It has been documented that *L. europaeus* can be parasitized by *V. album* (hyperparasitism) (Grazi & Urech, 1985). *Loranthus europaeus* itself may also occasionally exhibit auto-parasitism, where seedlings establish on branches already infested by mature individuals (Gebauer, personal observation).



FIGURE 16 Germinating seed and young *Loranthus europaeus* seedlings. (a) Firmly attached germinating seed. Hypocotyls are not visible. (b) Penetration site where the seedling grows through the bark. At this stage of growth, the seedling is not yet firmly attached to the host. (c) Established seedlings 2 years old. (d) Established seedlings 3–4 years old. Photographs by Roman Plichta.

TABLE 4 Recorded insect parasites on *Loranthus europaeus* (Ellis, 2001–2025).

Parasite	Family	Organ	Parasitic mode	Main group	Group
Koroneaspis aegylopos	Diaspididae		Scale	Insecta	Hemiptera Coccoidea
Acalypris loranthella	Nepticulidae	Leaf	Miner	Insecta	Lepidoptera
Aphis fabae fabae	Aphididae	Leaf	Free	Insecta	Hemiptera Sternorrhyncha
Cacopsylla visci	Psyllidae	Leaf	Gall	Insecta	Hemiptera Sternorrhyncha
Pinalitus coccineus	Miridae	Leaf	Free	Insecta	Hemiptera Heteroptera
Pinalitus viscicola	Miridae	Leaf	Free	Insecta	Hemiptera Heteroptera
Agrilus kubani	Buprestidae	Stem	Borer	Insecta	Coleoptera
Agrilus roscidus	Buprestidae	Stem	Borer	Insecta	Coleoptera
Chionaspis salicis	Diaspididae	Stem	Gall	Insecta	Hemiptera Coccoidea
Synanthedon loranthi	Sesiidae	Stem	Borer	Insecta	Lepidoptera
Tetrops praeustus	Cerambycidae	Stem	Borer	Insecta	Coleoptera

9.3 | Plant diseases

Three saprotrophic fungal species have been recorded on *L. europaeus* (Ellis, 2001–2025) (Table 5). Ascomycota includes two species: *Circinotrichum maculiforme* (Coniocessiaceae), which occurs on leaves, and *Diatrype disciformis* (Diatrypaceae), found on stems (Table 5). Basidiomycota is represented by *Peniophora nuda* (Peniophoraceae), a stem-inhabiting saprotroph. These fungi are not known to cause direct pathogenic damage to living tissues, but they play a role in the decomposition and nutrient cycling within the mistletoe ecosystem.

No fungal, bacterial or viral pathogens have been reported to infect *L. europaeus* or other *Loranthus* species. This lack of documented disease may be due to limited research rather than true resistance.

10 | HISTORY

The taxonomic history of *L. europaeus* is complex. Originally described by Jacquin in 1762, the species has undergone several reclassifications and has been known under various synonyms, including *Scurrula parasitica*, *Loranthus dioicus* and *Hyphear europaeum*

TABLE 5 Recorded saprotrophic fungal species on *Loranthus europaeus* (Ellis, 2001–2025).

Parasite	Family	Organ	Parasitic mode	Main group	Group
Circinotrichum maculiforme	Coniocessiaceae	Leaf	Saprotrophic	Fungi	Ascomycota
Diatrype disciformis	Diatrypaceae	Stem	Saprotrophic	Fungi	Ascomycota
Peniophora nuda	Peniophoraceae	Stem	Saprotrophic	Fungi	Basidiomycota

(Balle et al., 1960). Advances in molecular phylogenetics have clarified its placement within the family Loranthaceae, genus *Loranthus* (Nickrent et al., 2010, 2021).

Loranthus europaeus has been used for centuries in traditional medicine across its native range in Europe and western Asia (Ambrosio et al., 2020; Benabderrahim et al., 2019; Sharquie et al., 2016). Extracts from its fruits, leaves and twigs have been applied for their antimicrobial, anti-inflammatory and wound-healing properties (Ambrosio et al., 2020; Çömlekçioğlu et al., 2024; Jawad et al., 2007; Sharquie et al., 2016). Recent research has confirmed the pharmacological potential of *L. europaeus*, identifying a wide range of bioactive compounds with therapeutic properties. These include flavonoids (quercetin, rutin, epicatechin), phenolic acids, alkaloids, terpenes and essential oils (Aidy et al., 2022; Bampali et al., 2024; Benabderrahim et al., 2019; Katsarou et al., 2012). Extracts of *L. europaeus* have also shown antiproliferative effects in vitro, suggesting potential applications in cancer therapy (Benabderrahim et al., 2019). Given its diverse pharmacological profile, *L. europaeus* is a promising candidate for further research into natural therapeutic agents.

11 | CONSERVATION AND MANAGEMENT

Loranthus europaeus presents a unique management dilemma: while it is a driver of tree mortality in many oak-dominated forests, it also plays an important ecological role by supporting biodiversity. It provides food for frugivorous birds in winter, attracts pollinators and contributes to structural complexity in forest canopies (Cramp & Perrins, 1994; Watson, 2001). As such, its management must balance ecological benefits with the need to mitigate its negative impacts on host trees and forest productivity (Norton & Reid, 1997).

Furthermore, climate change is expected to significantly influence the distribution and dynamics of *L. europaeus* (Baranowska et al., 2025; Doležal et al., 2016; Saraj et al., 2015). Rising temperatures and altered precipitation patterns may expand its range into previously unsuitable areas (Baranowska et al., 2025; Sayad et al., 2017). Under future climate conditions, *L. europaeus* is expected to expand its range into northern and eastern Europe, as well as in the United Kingdom, due to the observed link between temperature and its distribution (Baranowska et al., 2025). In contrast, southern Europe may experience a decline in suitable habitats for the species (Baranowska et al., 2025).

Concerns about rising infestation levels are not new; as early as 1986, Göstel et al. (1986) warned about the spread of *L. europaeus* infestation on *Quercus* species in Austria. In some regions, infestation rates have increased dramatically in recent decades (e.g. from 25% to 78% in Iran between 2009 and 2013) (Saraj et al., 2015). However, declines in infestation have also been reported, such as in Czechia (Kubíček et al., 2018), illustrating that regional dynamics may not follow a uniform trend.

Monitoring is a key component of effective management. Regular surveys and mapping of infected areas help track changes in mistletoe abundance and identify infestation hotspots (Kubíček et al., 2018; Saraj et al., 2015). This information is essential to develop targeted control strategies and understand the dynamics of mistletoe–host interactions. However, several methodological constraints limit the precision of current survey approaches. Infestation patterns are typically strongly aggregated because bird dispersers repeatedly deposit seeds on already infected trees, creating fine-scale clusters that may be missed by coarse grid-based surveys (Matula et al., 2015; Saraj et al., 2015). Infestation probability is also strongly shaped by host traits such as tree size, crown openness and stand density; surveys that ignore these structural attributes risk misinterpreting infestation patterns (Kubíček et al., 2018; Kumbasli et al., 2011). Geostatistical interpolation methods, including IDW and Kriging, produce low mapping errors, with Kriging offering the most reliable spatial predictions and identifying an optimal transect spacing of 137 m for efficient sampling (Saraj et al., 2015). Because infestation levels can increase or decline over time, long-term monitoring is required to resolve temporal trends. The timing of the survey also affects the precision: winter provides the best detectability, as the fall of the leaf from host oaks exposes the deciduous mistletoe shrubs and their persistent fruits. Finally, remote-sensing technologies—particularly drone-based LiDAR and machine-learning classifiers—now enable high-resolution crown-level detection and provide a valuable complement to ground-based surveys, especially in dense stands or areas that are otherwise difficult to access.

Mechanical control, particularly pruning of infected branches, has proven effective in urban and small-scale forest settings (Hosseini, 2015; Sayad et al., 2017). It is recommended that pruning should be performed before fruit ripening to prevent seed dispersal. This method is cost-effective and relatively easy to implement, though it is less practical in large, forested areas. To prevent reinfestation, cut surfaces should be treated with sealing agents such as clay or glue-based compounds (Hosseini, 2015).

In forest stands, preventive silvicultural strategies are essential to reduce mistletoe establishment. Less dense stands and older trees are more susceptible to infestation, suggesting that maintaining optimal stand density may reduce mistletoe prevalence (Kubíček et al., 2018; Kubov et al., 2020; Matula et al., 2015). Protecting young trees from drought stress through appropriate silvicultural practices

may also enhance host resistance. Harvesting infested trees must be done to prevent the formation of seed sources and the development of hotspots, as *L. europaeus* has an aggregated spatial distribution (Eliáš, 1987; Matula et al., 2015; Sayad et al., 2017). Nevertheless, even well-managed stands can be reinfested from nearby infested trees. Landscape-scale coordination is therefore necessary, especially in fragmented forests or near urban areas where bird activity is high (Hosseini, 2015).

Despite its parasitic nature, *L. europaeus* plays a role in supporting biodiversity by providing food and habitat for birds and insects. In such cases, conservation efforts should focus on habitat protection and maintaining viable populations. Therefore, complete eradication is not always desirable. Integrated management approaches that combine monitoring, selective removal and habitat management are recommended to balance ecological benefits with forest health.

12 | GLOBAL HETEROGENEITY

The ecology of *L. europaeus* differs across its Eurasian range due to regional variation in climate, host composition and stand structure (see Sections 1–3). In central and south-eastern Europe, it occupies open, thermophilous oak woodlands dominated by ring-porous *Quercus* spp., where it can become abundant and exert notable impacts on stand structure and host vitality (Bratanova-Doncheva et al., 2005; Eliáš, 1987; Gebauer et al., 2012). Towards the north-eastern range margin, particularly in western Ukraine, it occurs at very low densities as small, isolated populations (Krasylenko et al., 2019). In these regions, the species is considered rare and of conservation interest rather than a silvicultural pest. Such marginal occurrences highlight its sensitivity to cooler climates and low light, which constrain recruitment and fruit maturation (see Section 5.3). In south-western Asia, *L. europaeus* follows a different ecological pattern, inhabiting higher elevations (up to 2130 m a.s.l.) (Benabderrahim et al., 2019; Sayad et al., 2017). In Iran, the severity of infestion increases with elevation across oak species (Navidi et al., 2016), contrasting with the decrease in the intensity of infestion observed in lowland European populations (Baranowska et al., 2025). Regional host specificity also varies, as in Turkey *Q. petraea* is heavily infested, while *Q. cerris*, a common host in Europe (Eliáš, 1988; Millaku et al., 2011; Zebec & Idžojtić, 2006), remains uninfected (Kumbasli et al., 2011). Large-scale distribution modelling predicts that continued climate warming will shift *L. europaeus* suitable environmental envelope northward and eastward, while reducing habitat suitability in parts of southern Europe (Baranowska et al., 2025).

Despite these emerging patterns, comparative information on *L. europaeus* global heterogeneity remains remarkably limited. Robust cross-regional studies integrating host physiology, climate drivers, dispersal processes and stand structure are still lacking, and future research should prioritize coordinated, multi-site investigations across *L. europaeus* Eurasian range to clarify the mechanisms underlying this geographic variation.

AUTHOR CONTRIBUTIONS

Roman Gebauer conceived the ideas and wrote the manuscript.

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The author declares no conflict of interest.

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