Appendix A

Harmonia^{+PL} – procedure for negative impact risk assessment for invasive alien species and potentially invasive alien species in Poland

QUESTIONNAIRE

A0 | Context

Questions from this module identify the assessor and the biological, geographical & social context of the assessment.

a01. Name(s) of the assessor(s):

first name and family name

1. Katarzyna Zając
2. Kamila Zając – external expert
3. Karolina Mazurska

acomm01. Comments:

	degree	affiliation	assessment date
(1)	dr	Institute of Nature Conservation, Polish Academy of Sciences in Cracow	17-04-2018
(2)	mgr	Institute of Environmental Sciences, Jagiellonian Univeristy, Kraków	08-05-2018
(3)	mgr	Institute of Nature Conservation, Polish Academy of Sciences in Cracow	10-05-2018

a02. Name(s) of ***the species*** under assessment:

Polish name: Ślinik luzytański

Latin name: ***Arion lusitanicus*** Mabille, 1868

English name: Iberian slug

Współfinansowano w ramach projektu nr POIS.02.04.00-00-0100/16 pn. *Opracowanie zasad kontroli i zwalczania inwazyjnych gatunków obcych wraz z przeprowadzeniem pilotażowych działań i edukacją społeczną* ze środków Unii Europejskiej w ramach Programu Infrastruktura i Środowisko 2014-2020

acomm02. Comments:

For many years, the name *Arion lusitanicus* Mabille 1868, which was marked in France in 1956 (Regteren Altena 1956 – P), was used to describe the invasive species of slugs. The range of occurrence of this species has been observed to include further sites located in various European countries. The designation of invasive slug as *A. lusitanicus* was wrong, which was confirmed by later genetic studies and morphology of reproductive organs (Castillejo 1997, Quinteiro et al. 2005, Pfenninger et al. 2014, Zemanova et al. 2016 – P). *Arion lusitanicus* Mabille, 1868 is endemic to the Iberian Peninsula (Portugal) and is not an invasive species (Quinteiro et al. 2005 – P). It belongs to the group of large slugs of the *Arion* genus (*A. ater* (Linnaeus, 1758); *A. rufus* (Linnaeus, 1758); *A. lusitanicus* Mabille, 1868; *A. flagellus* Collinge, 1893 and *A. vulgaris* Moquin-Tandon, 1855 (=*lusitanicus* auct. non Mabille), which have often been confused with each other, and require some indication and examination of internal organs and / or genetic testing (Rowson 2017 – B). To determine the invasive species of *A. lusitanicus* auct. non-Mabille, the use of the name *A. vulgaris* Moquin-Tandon was recommended, 1855 (Falkner et al. 2002, Anderson 2005 – P).

Polish name (synonym I)	Polish name (synonym II)
Ślimak lusytjański	–
Latin name (synonym I)	**Latin name (synonym II)**
Arion vulgaris	*Arion ater*
English name (synonym I)	**English name (synonym II)**
Lusitanian slug	Spanish slug

a03. **Area** under assessment:

Poland

acomm03. Comments:

–

a04. **Status** of *the species* in Poland. *The species* is:

	native to Poland
	alien, absent from Poland
	alien, present in Poland only in cultivation or captivity
	alien, present in Poland in the environment, not established
X	alien, present in Poland in the environment, established

aconf01. Answer provided with a

low	medium	high	level of confidence
		X	

acomm04. Comments:

The Iberian slug is found throughout the territory of Poland, for the first time it was noticed on fruit cultivation in Albigowa near Rzeszów (podkarpackie voivodeship), where it appeared in 1987 (R. Sionek, as cited in Stworzewicz and Kozłowski 2012 – P). In the following years, the presence of the Iberian slug was found at new positions in Albigowa, in the neighboring town of Markowa, as well as at several positions in Rzeszów and Łańcut (Kozłowski and Kornobis 1994, 1995, Kozłowski 2000a – P). In 1997-1999, the presence of this species was found at 93 sites in 23 towns located on the Rzeszów and Dynowskie Foothills (Kozłowski 2000a – P). In 1997, a new site for the occurrence of the Iberian slug in Małujowice near Brzeg (Opole Voivodeship) was found, and in 1999 in Górachowice Górne near Wieliczka (Lesser Poland) (Kozłowski 2001 – P). The conducted research confirms the hypothesis that the range of this slug is spreading throughout the country, in recent years its subsequent positions have been noted all over Poland (Podkarpackie, Lesser Poland, Lubuskie, Śląskie, Opolskie, Łódzkie, Greater Poland, Pomeranian, Warmian-Mazurian and Mazowieckie voivodships), where it appears numerously (Kozłowski and Kornobis 1994, 1995, Kozłowski 1995, 2000a, 2001, 2008, Kozłowski and Sionek 2000, Kozłowski et al. 2008 – P). On some of these sites, this species occurred outside crops, in forests and undergrowth, located near watercourses and reservoirs.

a05. The impact of *the species* on major domains. *The species* may have an impact on:

X	the environmental domain
X	the cultivated plants domain
X	the domesticated animals domain
X	the human domain
	the other domains

acomm05. Comments:

The Iberian slug has a negative impact on the natural environment and plant cultivation, it is one of the most dangerous pests of vegetable, ornamental, agricultural, fruit and herbal crops (Kozłowski 2010, 2012a, 2012b – P), but also herbaceous plants, wild growing near cultivation for example, ground elder (*Aegopodium podagraria*) (Kozłowski and Kozłowska 2000 – P). It may cause displacement of native species of slugs while increasing their range, searching for new places for laying eggs, foraging and hiding (Kozłowski 2008 – P). The Iberian slug feeds on dead plant and animal tissues, however, it is known that it can be a predator of nestlings (Sklepowicz 2008, Leniowski et al. 2013, Turzańska and Chachulska 2015, 2017 – P). The Iberian slug is a vector for plant pathogens (Weidema 2006, Hatteland 2010, Peltanová et al. 2011, Kozłowski 2012a, b, Slotsbo 2012 – P) and a vector of various organisms, e.g. nematodes, both free-living (Petersen et al. 2015 – P), as well as parasitic (e.g., *Angiostrongylus vasorum*) (South 1992, Ferdushy et al. 2010 – P). It can also transfer other vertebrate parasites (e.g. *Brachylaemus flukes*). The Iberian slug is numerous in moist and rich in food environments, affecting the deterioration of the physical condition of animals. High population density of this species may cause contamination of grass silage and pose a potential threat to the safety and quality of animal feed (Gismervik et al. 2014, 2015 – P). In addition, the use of methods of combating this slug, such as the use of chemicals and molluscicides, can be dangerous for domestic animals and cattle (Edwards et al 2009 – P).

The Iberian slug is a vector of dangerous pathogens and parasites. It was found that this species can carry bacteria, e.g. *Clostridium botulinum* causing botulism (Gismervik et al., 2014 – P), or *Listeria monocytogenes* responsible for listeriosis (Gismervik et al. 2015 – P).

A1 | Introduction

Questions from this module assess the risk for *the species* to overcome geographical barriers and – if applicable – subsequent barriers of captivity or cultivation. This leads to *introduction*, defined as the entry of *the organism* to within the limits of *the area* and subsequently into the wild.

a06. The probability for ***the species*** to expand into Poland's natural environments, **as a result of self-propelled expansion** after its earlier introduction outside of the Polish territory is:

	low
	medium
X	high

aconf02. Answer provided with a

low	medium	high	level of confidence
		X	

acomm06. Comments:

The Iberian slug is present and established in Poland since the late 1980s. It has the ability to move independently and naturally. It was first recorded at the areas of the Podkarpackie Voivodeship, from where it spread to other areas of Poland (Kozłowski and Kornobis 1994, 1995 – P). It occurs mainly in agricultural and horticultural crops, from where it permeates to habitats changed by human activities (e.g. surroundings of buildings, wastelands, roadside), but also to more natural habitats, e.g. thickets in river valleys (Stworzewicz and Kozłowski 2012 – P). The range of this type of independent, spontaneous expansion is relatively small, but effective due to the high fertility of the species (Crerzewicz and Kozłowski 2012 – P). Its

high resistance to environmental conditions helps it in taking over new positions (Slotsbo et al. 2011a, 2011b, 2012, 2013 – P). Currently, the Iberian slug has a large presence throughout the country, it also occurs in countries neighboring Poland (Germany, Slovakia, the Czech Republic, Ukraine, Lithuania) (Zemanova et al. 2016, Zając et al. 2017 – P).

a07. The probability for *the species* to be introduced into Poland's natural environments by **unintentional human actions** is:

	low
	medium
X	high

aconf03.	Answer provided with a	low	medium	high **X**	level of confidence

acomm07. Comments:

The Iberian slug is established in Poland. The original area of occurrence of this species is Spain, Portugal and the Azores, from where it began to expand to the rest of Europe (Simroth 1891, Quick 1952, 1960, Regteren Altena 1971, Chevallier 1972 – P). Currently, it is present in most European countries, such as France, Great Britain, Germany, Slovenia, Switzerland, Sweden, Austria, Bulgaria, Croatia, Estonia, Hungary, Spain, Norway, Belgium, Ukraine, the Netherlands, Finland, Denmark, Poland and Iceland, Greenland, Romania, Italy, Lithuania, Latvia and Faroe Islands (Quick 1952, 1960, Ellis 1965, Schmid 1970, Regteren Altena 1971, Riedel and Wiktor 1974, Davies 1987, Winter de 1989, Proschwitz 1992, 1994, Proschwitz and Winge 1994, Wiktor 1996, Weidema 2006, Kozłowski 2007, Slotsbo 2012, Păpureanu et al. 2014, Zemanova and others 2016 – P). Expansion of the Iberian slug to other European countries was a result of the natural expansion of the species and human activity (Pfenninger et al. 2014, Zemanova et al. 2016 – P). The Iberian slug appears in new habitats along with the transport of cuttings and/or crops, land, municipal waste or with means of transport (Proschwitz and Winge 1994, Kozłowski 2007 – P). Both eggs, as well as adults and juveniles are sometimes transported to new positions unnecessarily (Crerzewicz and Kozłowski 2012 – P, Slotsbo 2014 – B). Genetic studies carried out in 2006 on the Polish population of the Iberian slug showed great intergenerational diversity. This indicates that its origin is heterogeneous and may be the result of multiple, independent introductions to Poland from various positions in Western Europe (Soroka et al. 2009 – P).

a08. The probability for *the species* to be introduced into Poland's natural environments by **intentional human actions** is:

	low
	medium
X	high

aconf04.	Answer provided with a	low	medium	high **X**	level of confidence

acomm08. Comments:

The Iberian slug is established in Poland, which according to the *Harmonia*$^{+PL}$ risk assessment methodology, indicates the choice of response: high probability, with a high degree of certainty. At the same time, it should be emphasized that there are no premises stating that the Iberian slug could have been introduced into the natural environment due to intentional human activities, this species has never been the object of economic interest.

A2 | Establishment

Questions from this module assess the likelihood for *the species* to overcome survival and reproduction barriers. This leads to *establishment*, defined as the growth of a population to sufficient levels such that natural extinction within *the area* becomes highly unlikely.

a09. Poland provides **climate** that is:

	non-optimal
	sub-optimal
X	optimal for establishment of *the species*

aconf05.	Answer provided with a	low	medium	high **X**	level of confidence

acomm09. Comments:

Since the 1950s, increasing the range of the presence of the Iberian slug in the European countries has been observed (Quick 1952, Kerney and Cameron 1979, Proschwitz 1992, Proschwitz and Winge 1994, Kozłowski 2007 – P). Initially, it was assumed that this slug comes from the Iberian Peninsula, however, genetic studies have shown that this area is inhabited by an endemic species morphologically similar to the invasive slug (Quinteiro et al. 2005 – P). The place of origin of the Iberian slug is not exactly known, however, the results of genetic tests indicate that it is probably western Europe (Pfenninger et al 2014, Zemanova et al 2016 – P). The Iberian slug has a wide range of tolerance to climatic conditions, as evidenced by its occurrence both in the north and south of Europe, where environmental conditions differ significantly (Rabitsch 2006 – B, Weidema 2006 – P). The map of the climatic similarity of Poland in relation to the whole world developed by modeling using the distance of Mahalanobis shows that the values of climatic similarity are in the range of 94-100%, thus climate requirements of the species are fully met in Poland.

a10. Poland provides **habitat** that is

	non-optimal
	sub-optimal
X	optimal for establishment of *the species*

aconf06.	Answer provided with a	low	medium	high **X**	level of confidence

acomm10. Comments:

The Iberian slug found appropriate habitat conditions for survival and reproduction in Poland. It occurs in deciduous and mixed forests, as well as in anthropogenic environments characterized by strong degradation (Proschwitz 1994, Kozłowski 2005 – P). It can be found in cemeteries, meadows, wastelands, parks, bushes, on the banks of rivers, rubbish dumps, in road ditches (Kozłowski 2000c, Kozłowski and others 2008 – P, Slotsbo 2014 – B). It occurs in places moist and rich in food (e.g. shadowed slopes of watercourses, ditches), where the density can be 100 individuals/m^2. It is also present in agricultural, fruit-growing, herbal, ornamental crops, on plantations, where it is a serious threat to cultivated plants (Kozłowski 2010 – P). The Iberian slug spawns in Poland, lives through a period of winter and creates numerous, permanent populations, which indicates that the habitat conditions are optimal for it. This species is established in Poland (Stworzewicz and Kozłowski 2012 – P).

A3 | Spread

Questions from this module assess the risk of *the species* to overcoming dispersal barriers and (new) environmental barriers within Poland. This would lead to spread, in which vacant patches of suitable habitat become increasingly occupied from (an) already-established population(s) within Poland.

Note that spread is considered to be different from range expansions that stem from new introductions (covered by the Introduction module).

a11. The capacity of *the species* to disperse within Poland by natural means, **with no human assistance**, is:

	very low
	low

	medium
X	high
	very high

aconf07.	Answer provided with a	low	medium	high **X**	level of confidence

acomm11. Comments:

Dispersion from a single source (Data type: A)
The Iberian slug appeared in Poland in 1987, in the Podkarpackie Voivodeship, in orchard cultivations in Albigowa (R. Sionek, as cited in Stworzewicz and Kozłowski 2012 – P). In the following years, the presence of the Iberian slug was found at new positions in Albigowa, in the neighboring town of Markowa, and also at several positions in Rzeszów and Łańcut (Kozłowski and Kornobis 1994, 1995, Kozłowski 1995, 2000a – P). Further positions of the Iberian slug were recorded all over the country: in the Podkarpackie Voivodeship – Wysoka, Łańcut, Rzeszów (1994), Przeworsk (1995), Jarosław, Głuchów (1996), Zabratówka, Zarzecze, Boguchwała (1997), Korczyna (2005); Lesser Poland – Poznań (2000), Zawadka (2006), Bobrek, Wadowice (2007); Opole – Małujowice (2001); śląskie – Pisarzowice, Bielsko-Biała (2006); Łódź – Łódź, Wołodrza (2007); Greater Poland – Leszno (2007); Pomeranian – Prabuty (2007); Warmia and Mazury – Gronowo Górne (2007); Mazowieckie – Podkowa Leśna (2007) (Kozłowski et al. 2008 – P). The detection of subsequent sites of this species shortly after its appearance in the territory of the country testifies to its large ability to spread in Poland without human participation. The greatest number of Iberian slugs is found in agricultural and horticultural crops, which from there spontaneously, without human participation, it colonizes moist habitats with herbaceous vegetation and bushes, as well as forests over waters (Kozłowski 2008, Stworzewicz and Kozłowski 2012 – P). It is a relatively mobile slug, more so than the non-invasive, native species of the great *Arion rufus* (Knop et al. 2013 – P). The Iberian slug moves at a speed of 5-9 m/h (Rabitsch 2006 – B). The annual distance covered by the slug estimated on this basis can be greater than 5 km, so its ability to spread without human involvement is high.

a12. The frequency of the dispersal of *the species* within Poland by **human actions** is:

	low
	medium
X	high

aconf08.	Answer provided with a	low	medium	high **X**	level of confidence

acomm12. Comments:

The spread of the Iberian slug due to intentional and unintended human actions covers over ten cases per decade (Kozłowski and Kozłowski 2011 – P) and increases. This species is spread with the participation of humans with a high frequency during the transport of plants for sale (Weidema 2006 – P). Adult specimens and eggs of the Iberian slug are regularly found in transported goods (arable, potted plants, garden materials, boxes, etc.) (Weidema 2006, Leewis et al. 2013 – P). The frequency with which the Iberian slug is spreading in Poland with human participation is high.

A4a | Impact on the environmental domain

Questions from this module qualify the consequences of *the species* on wild animals and plants, habitats and ecosystems.

Impacts are linked to the conservation concern of targets. Native species that are of conservation concern refer to keystone species, protected and/or threatened species. See, for example, Red Lists, protected species lists, or Annex II of the 92/43/EWG Directive. Ecosystems that are of conservation concern refer to natural systems that are the habitat of many threatened species. These include natural forests, dry grasslands, natural rock outcrops,

sand dunes, heathlands, peat bogs, marshes, rivers & ponds that have natural banks, and estuaries (Annex I of the 92/43/EWG Directive).

Native species population declines are considered at a local scale: limited decline is considered as a (mere) drop in numbers; severe decline is considered as (near) extinction. Similarly, limited ecosystem change is considered as transient and easily reversible; severe change is considered as persistent and hardly reversible.

a13. The effect of *the species* on native species, through **predation, parasitism or herbivory is**:

	inapplicable
	low
X	medium
	high

aconf09.	Answer provided with a	low	medium	high **X**	level of confidence

acomm13. Comments:

The Iberian slug causes huge damage to agricultural and garden crops (Kozłowski 2005 – P). Spreading in neighboring habitats, it causes the smallest drop in the population size of native, special care species. The Iberian slug may reduce plant biodiversity; in Łańcut (Podkarpackie Voivodeship), the presence of this species led to the total destruction of the wild growing ground elder (*Aegopodium podagraria*) (Kozłowski and Kozłowska 2000 – P), which is considered to be native species in Polish fauna (Rutkowski 2006 – P). Co-occurring plants in this area, less attractive as food for the slug, have not been this damaged (Kozłowski and Kozłowska 2000 – P). This species is the predator of chicks in nests, the cases were found, for example, in *Acrocephalus palustris* (Sklepowicz 2008 – P), *Sylvia communis* (Turzańska and Chachulska 2015 – P), *Sylvia atricapilla* (Leniowski et al. 2013 – P), belonging to species of special care.

a14. The effect of *the species* on native species, through **competition** is:

X	low
	medium
	high

aconf10.	Answer provided with a	low	medium **X**	high	level of confidence

acomm14. Comments:

The Iberian slug can displace other species of slugs, it competes with the native species – a red slug, not belonging to special care species (Kozłowski 2008 – P). Such a case was noted in the position located in allotment gardens in Rzeszów, where in years 1993-1998 a red slug appeared, and after 2002 in the same place only individuals of the Iberian slug (Crerzewicz and Kozłowski 2012 – P) were found. This competition may lead to small decreases in the size of the population of the red slug, therefore the impact of the Iberian slug on native species through competition can be described as small. However, no detailed research is available, especially in more natural habitats.

a15. The effect of *the species* on native species, through **interbreeding** is:

	no / very low
	low
	medium
X	high
	very high

aconf11.	Answer provided with a	low	medium	high **X**	level of confidence

acomm15.	Comments: This species can have an impact on native species through hybridization. There are known cases of crossbreeding of the Iberian slug with native species of nude slugs (Roth et al. 2012, Dreijers et al. 2013, Zemanova et al. 2017 – P). It is possible to cross the Iberian slug with the red slug, which is a native species in Poland. The Iberian slug and the red slug are morphologically similar species of up to 15 cm in size, which are indistinguishable without performing the section and comparing the anatomical features of copulatory organs (Riedel and Wiktor 1974, Wiktor 1989, 1996, 2004, Kozłowski 2010 – P). The probability of the influence of the Iberian slug on native species through crossbreeding can be described as high. However, the effect of this phenomenon should be described as average, because despite the fact that the Iberian slug can cause a serious loss of genetic coherence in the red slug, this species is not a species of special care.

a16. The effect of *the species* on native species by **hosting pathogens or parasites** that are harmful to them is:

	very low
	low
	medium
X	high
	very high

aconf12.	Answer provided with a	low	medium	high **X**	level of confidence

acomm16.	Comments: The Iberian slug is a vector of various organisms, e.g. nematodes, both free-living (Petersen et al 2015 – P), as well as parasitic ones, such as *Angiostrongylus vasorum*, which parasites in the pulmonary arteries, and canine and feline heart (South 1992 – P). It triggers angiostrongylosis, a disease that can occur in dogs, foxes, and less frequently in other carnivorous animals such as wolves, coyotes and felids (Ferdushy et al. 2010, Majoros et al. 2010, Frączyk and Gawor 2014, Tomczuk and Szczepaniak 2014 – P). This disease is treatable, but in extreme cases it can lead to death of an animal (Frączyk and Gawor 2014 – P). *A.vasorum* nematode was detected in *Canis lupus* wolves located in Bieszczady (Čabanová et al. 2017, Szczęsna et al. 2007 – P). The Iberian slug can be a vector of the nematode *Alloionema appendiculatum*, which is also a parasite in other species of land slugs (Laznik et al. 2009, 2010 – P). It can also transmit other vertebrate parasites, it is their intermediate host, for example, *Brachylaemus*, which adult forms are found in birds and some smaller mammals, such as hedgehogs and badgers. In the epithelium of the kidneys and lungs of the Iberian slug larvae of tapeworms of *Choanotaenia crassiscolex* and *C. estavarensis* were found, which adult forms parasitise on the common shrew *Sorex araneus* and water shrew *Neomys fodiens* (South 1992 – P). It was found that the Iberian slug can carry bacteria, e.g. *Clostridium botulinum* causing botulism (Gismervik et al. 2014 – P), and *Listeria monocytogenes* responsible for listeriosis (Gismervik et al. 2015 – P). Among other parasites of the Iberian slug there are nematodes *Phasmarhabditis hermaphrodita*, *Agfa flexilis*, *Angiostoma limacis*, *Angiostoma* sp. (Laznik et al. 2010, Ross et al. 2010, 2016 – P). The use of *P. hermaphrodita* is one of the methods of biological control of the Iberian slug and other species of slugs, mainly belonging to *Arionidae, Milacidae, Agriolimacidae, Limacidae* (Rae et al. 2007 – P). The use of Nemaslug biopreparation, which contains the parasitic nematode *Phasmarhabditis hermaphrodita* carrying *Moraxela osloensis* bacteria limits the feeding of slugs on plants and may also increase their mortality (Tan and Grewal 2001, Rae et al. 2007, 2009 – P). The impact on indigenous species caused by the passage of the pathogens and parasites by the Iberian slug can be described as large, because the mucus is a host and a vector of pathogens and parasites that infect native species, also belonging to special care species (*A. vasorum* is a parasite found in wolves (Szczęsna et al. 2007, Čabanová et al. 2017 – P), causing small decreases in the size of their population at the most.

a17. The effect of *the species* on ecosystem integrity, by **affecting its abiotic properties** is:

X	low
	medium
	high

aconf13.	Answer provided with a	low **X**	medium	high	level of confidence

acomm17. Comments:

There is no information on the impact of the species on the integrity of terrestrial ecosystems by interfering with their abiotic factors. However, it should be noted that so far no studies on this type of influence of the species have been conducted, even in cases of its mass occurrence, therefore it is uncertain whether such an effect exists, so the answer was given with a small degree of certainty.

a18. The effect of *the species* on ecosystem integrity, by **affecting its biotic properties** is:

X	low
	medium
	high

aconf14.	Answer provided with a	low	medium	high **X**	level of confidence

acomm18. Comments:

The possible negative impact of the Iberian slug on biotic factors of the ecosystem manifests itself in the displacement of the native species – the red slug in places of coexistence (Kozłowski 2008 – P). In addition, the Iberian slug can negatively affect the biodiversity of plants through herbivorousness (e.g. *Centaurea cyanus*, *Fagopyrum esculentum*, *Papaver rhoeas*) (Frank 1998, 2003 – P), and also cause the death of chicks of marsh warbler *Acrocephalus palustris* (Sklepowicz 2008 – P), common whitethroat *Sylvia communis* (Turzańska and Chachulska 2015 – P), blackcap *Sylvia atricapilla* (Leniowski et al. 2013 – P). On the other hand, slugs are important as food for other predatory animals, for example, slugs are victims of hedgehogs, toads, birds, as well as predatory beetles from the Carabidae family (South 1992, Pianezzola et al. 2012, Hatteland et al. 2013 – P). The occurence of the Iberian slug in the habitat as a new source of food for predators may cause their numbers to increase. In summary, the influence of the Iberian slug on the integrity of the ecosystem through the disruption of its biotic factors can be described as small, because this species causes easily reversible changes regarding processes occurring in habitats that do not belong to special care habitats.

A4b | Impact on the cultivated plants domain

Questions from this module qualify the consequences of *the species* for cultivated plants (e.g. crops, pastures, horticultural stock).

For the questions from this module, consequence is considered 'low' when presence of *the species* in (or on) a population of target plants is sporadic and/or causes little damage. Harm is considered 'medium' when *the organism's* development causes local yield (or plant) losses below 20%, and 'high' when losses range >20%.

a19. The effect of *the species* on cultivated plant targets through **herbivory or parasitism** is:

	inapplicable
	very low
	low
	medium
	high
X	very high

aconf15.	Answer provided with a	low	medium	high **X**	level of confidence

acomm19. Comments:

The Iberian slug is a serious pest of many vegetable, ornamental, agricultural, fruit and herb species (Kozłowski 2001, 2005, 2008, 2012a, 2012b, Kozłowski and Kozłowski 2010, Kozłowski and Jaskulska 2014 – P). It damages and eats young organs of plants, mainly germinating seeds, leaves, seedlings, shoots, tubers, roots and fruits. It also feeds on other herbaceous plants that grow on wasteland and in bushes in close proximity to crops. Damage caused by this snail was found on more than 30 species, including sunflower (*Helianthus annuus*), potatos (*Solanum tuberosum*), Persian clover (*Trifolium resupinatum*). During the germination period – in the crops of winter oilseed rape (*Brassica napus* ssp. *napus*) and winter wheat (*Triticum aestivum*). The Iberian slug causes an average of 6% to 15% of plant damage (Kozłowski 2008, 2012b – P). Among vegetables, the highest degree of damage is observed in the seedlings of lettuce (*Lactuca sativa* var. *capitata*), headed cabbage (*Brassica oleracea* var. *capitata* f. *alba*), napa cabbage (*B. rapa* ssp. *pekinensis*), beetroot (*Beta vulgaris* var. *conditiva*), carrot (*Daucus carota* ssp. *sativus*), parsley (Petroselinum crispum convar. *radicosum*) and beans (*Phaseolus vulgaris* var. *nanus*). The Iberian slug also causes damage to herbal and ornamental plants such as *Althaea rosea*, garden angelica *Archangelica officinalis*, dahlia *Dahlia variabilis*, Madonna lily *Lilium candidum*, basil *Ocimum basilicum*, cutleaf coneflower *Rudbeckia laciniata*, Mexican marigold *Tagates erecta*, youth-and-age *Zinnia elegans* and many others. It damages the leaves and fruits of strawberries and raspberries. It also destroys the ground elder *Aegopodium podagraria* and common nettle *Urtica dioica* (Kozłowski and Kozłowska 2000, Kozłowski 2008, 2012a, 2012b – P). After controlling the cultivation of 31 species of plants in which the presence of this slug was observed, it was found that crops of 15 species have destroyed more than 30% of plants, and in other cases the damage also occurs, however they are smaller (Kozłowski and Kozłowski 2011 – P). The Iberian slug causes huge damage to the crops of many plant species (high probability, large effect).

a20. The effect of *the species* on cultivated plant targets through **competition** is:

X	inapplicable
	very low
	low
	medium
	high
	very high

aconf16.	Answer provided with a	low	medium	high	level of confidence

acomm20. Comments:

The species is not a plant.

a21. The effect of *the species* on cultivated plant targets through **interbreeding** with related species, including the plants themselves is:

X	inapplicable
	no / very low
	low
	medium
	high
	very high

aconf17.	Answer provided with a	low	medium	high	level of confidence

acomm21.	Comments: The species is not a plant.

a22. The effect of *the species* on cultivated plant targets by **affecting the cultivation system's integrity** is:

X	very low
	low
	medium
	high
	very high

aconf18.	Answer provided with a	low	medium **X**	high	level of confidence

acomm22.	Comments: The Iberian slug will not affect the condition or yield of crop plants by changing the properties of the agro-ecosystem, including the circulation of elements, hydrology, physical properties, trophic networks, etc.

a23. The effect of *the species* on cultivated plant targets by hosting **pathogens or parasites** that are harmful to them is:

	very low
	low
X	medium
	high
	very high

aconf19.	Answer provided with a	low	medium	high **X**	level of confidence

acomm23.	Comments: The Iberian slug is a host or vector of pathogens and parasites harmful to plants. The impact of this species on crop cultivation has been estimated as average because at least one pathogen is included in the EPPO A2 list (*Phytophthora* fungi), which causes serious disease of plants (mainly agricultural, orchard, vegetables, trees and shrubs), called phytophthora. Telfer et al. (2015 – P) showed that hyphae of *Phytophthora plurivora* and *P. cambivora* causing phytophthora of beech trees retain their ability to grow after passing through the digestive system of the Iberian slug.

A4c | Impact on the domesticated animals domain

Questions from this module qualify the consequences of *the organism* on domesticated animals (e.g. production animals, companion animals). It deals with both the well-being of individual animals and the productivity of animal populations.

a24. The effect of *the species* on individual animal health or animal production, through **predation or parasitism** is:

	inapplicable
X	very low
	low
	medium
	high
	very high

aconf20.	Answer provided with a	low	medium	high **X**	level of confidence

acomm24.	Comments: The Iberian slug is an omnivorous animal, but plants dominate in its diet. It happens that there are acts of cannibalism, especially in the case of dead individuals (Zając et al. 2017 – P). This species may also affect populations of wild birds by predation on nestlings (Leniowski et al. 2013, Turzańska and Chachulska 2015 – P). Until now, the influence of the Iberian slug on the health of a single farm animal, domestic animal or animal production through predation or parasitism has not been recorded.

a25. The effect of *the species* on individual animal health or animal production, by having properties that are hazardous upon **contact**, is:

	very low
	low
X	medium
	high
	very high

aconf21.	Answer provided with a	low	medium **X**	high	level of confidence

acomm25.	Comments: The probability that farm or home animals may come into contact with the Iberian slug by being in the same environment is large. This is due to the fact that the Iberian slug is a widespread species in Poland and Europe. Domestic and farm animals may accidentally eat slugs, but the resulting effects are usually small. There have been reported cases of covering the beaks of ducks with slimy mucus, hindering the birds from functioning, and even single fatal choking / suffocation of ducks when the mucus has covered the inside of their throat and esophagus. Accordingly, the influence of the Iberian slug on the health of a single animal or animal production through its properties, which pose a danger during direct contact, was assessed as medium.

a26. The effect of *the species* on individual animal health or animal production, by hosting **pathogens or parasites** that are harmful to them, is:

	inapplicable
	very low
	low
	medium
X	high
	very high

aconf22.	Answer provided with a	low	medium	high **X**	level of confidence

acomm26.	Comments: The influence of the Iberian slug on the health of a single animal or animal production through the transmission of pathogens and parasites harmful to these animals is high. This is due to the fact that the slug, like other species of land slugs, is the intermediate host of the parasitic nematode *Angiostrongylus vasorum*, which final host is canine and felid (Ferdushy et al. 2010 – P). This nematode is parasitic in the blood vessels of the heart and lungs resulting in a potentially lethal disease of these animals. This disease is treatable, but in extreme cases it can lead to the death of an animal (Frączyk and Gawor 2014 – P). Dog examinations confirmed the presence of antigens and antibodies against *A. vasorum* in the blood of dogs from all over Poland, which indicates the contact with the parasite (Schnyder et al. 2013 – P). It was found that the Iberian slug may carry bacteria, e.g. *Clostridium botulinum* causing botulism (Gismervik et al. 2014 – P), or *Listeria monocytogenes*, responsible for listeriosis (Gismervik et al. 2015 – P). These studies were carried out in Sweden, where high densities can cause contamination of silos with plant feed (silage), posing a threat to the health of livestock.

A4d | Impact on the human domain

Questions from this module qualify the consequences of *the organism* on humans. It deals with human health, being defined as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (definition adopted from the World Health Organization).

a27. The effect of *the species* on human health through **parasitism** is:

X	inapplicable
	very low
	low
	medium
	high
	vert high

aconf23.	Answer provided with a	low	medium	high	level of confidence

acomm27. Comments:

The Iberian slug is not a human parasite.

a28. The effect of *the species* on human health, by having properties that are hazardous upon **contact**, is:

X	very low
	low
	medium
	high
	very high

aconf24.	Answer provided with a	low	medium **X**	high	level of confidence

acomm28. Comments:

The Iberian slug *Arion vulgaris/lusitanicus* can affect the mental condition of people causing them to be afraid or disgusted (phobia), but this state does not cause absenteeism or permanent damage to the body's functioning (Gustavson and Weight 1981-P), so the effect is small. Despite the fact that the probability of encountering *Arion vulgaris/lusitanicus* with humans is high, the probability of contact that will cause a phobia effect is low (in less than one man per 100,000 people per year). Therefore, the impact of the species on human health due to possessed properties that pose a danger during direct contact was rated as very small.

a29. The effect of *the species* on human health, by hosting **pathogens or parasites** that are harmful to humans, is:

	inapplicable
	very low
	low
	medium
	high
X	very high

aconf25.	Answer provided with a	low	medium	high **X**	level of confidence

acomm29. Comments:

The impact of the Iberian slug on human health as a result of the transmission of pathogens and parasites harmful to humans is very large; there is at least one co-pathogen / parasite for the Iberian slug and human, and the disease caused by this pathogen / parasite is very dangerous, it can lead to death. The Iberian slug may carry *Listeria monocytogenes*, which is responsible for the occurrence of a disease called listeriosis (Gismervik et al. 2015 – P). In

	immunocompromised people, in small children and the elderly, listeriosis may have a severe course and lead to death. The Iberian slug can be a vector of *Clostridium botulinum*, which causes botulism (Gismervik et al. 2014 – P). 10-25% are serious cases of poisoning that cannot be cured. These diseases also affect humans, because pathogens can enter the human body through the consumption of food contaminated by the slug. In addition, the Iberian slug may be a vector of pathogenic bacteria, for example some strains of *Escherichia coli* (Stalder i in. 2014 – P), as well as an intermediate host of the parasitic nematode *Angiostrongylus cantonensis*, which causes the disease – eosinophilic meningitis (Grewal et al. 2003 – P). This parasite is mainly found in the tropics, but has recently spread throughout the world and cases have been found in Europe (Luessi et al. 2009, Maretić et al 2009, Martin-Alonso et al. 2015, Fellner et al 2016, Cowie 2017 – P). This parasite was included in the European ranking of human parasites carried along with food (Bouwknegt and others 2018 – P). The possible impact of the Iberian slug on the spread of this parasite has not been studied in detail. Potentially, the Iberian slug can be a vector of pathogenic nematode *A. cantonensis*, because it spreads with crop plants and food products that could contaminate, and now one can indicate the areas, where both species occur simultaneously and where the slug could become infected.

A4e | Impact on other domains

Questions from this module qualify the consequences of *the species* on targets not considered in modules A4a-d.

a30. The effect of *the species* on causing damage to **infrastructure** is:

X	very low
	low
	medium
	high
	very high

aconf26.	Answer provided with a	low	medium **X**	high	level of confidence

acomm30.	Comments: There is no data to indicate that the Iberian slug has or could have a detrimental effect on the infrastructure. It is true that during creeping it leaves behind a trail of mucus (low probability), but it does not affect the infrastructure (small effect), hence the impact of the species on the infrastructure is very small.

A5a | Impact on ecosystem services

Questions from this module qualify the consequences of *the organism* on ecosystem services. Ecosystem services are classified according to the Common International Classification of Ecosystem Services, which also includes many examples (CICES Version 4.3). Note that the answers to these questions are not used in the calculation of the overall risk score (which deals with ecosystems in a different way), but can be considered when decisions are made about management of *the species*.

a31. The effect of *the species* on **provisioning services** is:

X	significantly negative
	moderately negative
	neutral
	moderately positive
	significantly positive

aconf27.	Answer provided with a	low	medium	high **X**	level of confidence

acomm31. Comments:

The Iberian slug has a very negative impact on the supply services; affects food delivery services. The species is a serious pest of many vegetable species, ornamental, agricultural, fruit and herbal plants (Kozłowski and Kozłowska 2000, Kozłowski and Sionek 2000, Kozłowski 2005, 2008, 2012, Kozłowski and Kozłowski 2010 – P). In addition, it affects the farming of domestic and farm animals, because it can be a vector of pathogens and parasites (Ferdushy et al. 2010, Gismervik et al. 2014, 2015 – P). The Iberian slug damages and eats young plant organs, mainly germinating seeds, leaves, seedlings, shoots, tubers, roots and fruits. Through its foraging, it can damage plants used for energy purposes, such as sunflower (*Helianthus annuus*), oilseed rape (*Brassica napus var. Napus*) (Kozłowski and Jaskulska 2014 – P).

a32. The effect of *the species* on **regulation and maintenance services** is:

	significantly negative
	moderately negative
X	neutral
	moderately positive
	significantly positive

aconf28.	Answer provided with a	low	medium	high **X**	level of confidence

acomm32. Comments:

The Iberian slug affects regulatory services related to biological regulation, both negatively and positively. The negative impact is related to the transmission of human and animal and plant pathogens, e.g. the slug is a host and vector of parasites that infect native species, also belonging to special care species (*A. vasorum* nematode is a parasite found in wolves (Szczęsna et al. 2007, Čabanová et al. 2017 – P), causing small decreases in the size of their population at the most). It affects the regulation of zoonotic diseases in humans, it is the intermediate host of the parasitic nematode *Angiostrongylus cantonensis*, which causes eosinophilic meningitis (Grewal et al. 2003 – P). At the same time, this species has a positive effect on regulatory services related to biological regulation, such as: (1) the spreading of plants by transferring diasporas (e.g. diasporas eaten by certain species of native bryophytes, ferns and seed plants are transferred to new areas and get to environment with snail feces (Türke et al. 2010, 2013, Boch et al. 2013, 2016 – P); (2) reducing the number of species – pests of plants grown by humans (e.g., the presence of cabbage plants increases the mortality of the pest – *Pieris brassicae* (Desurmont et al. 2016 – P), but also the slug foraging on the crop damages some weeds (e.g. *Centaurea cyanus*, *Fagopyrum esculentum*, *Papaver rhoeas*, Frank 1998, 2003 – P); (3) increasing the number of native protected species (e.g. the protected native carnivorous beetles, including *Carabus nemoralis* (Hatteland et al. 2013 – P), which eats eggs and juveniles). Due to the fact that it is impossible to assess simultaneously the positive and negative impact, the "neutral" assessment was recommended.

a33. The effect of *the species* on **cultural services** is:

	significantly negative
	moderately negative
X	neutral
	moderately positive
	significantly positive

aconf29.	Answer provided with a	low **X**	medium	high	level of confidence

acomm33.	Comments: The Iberian slug has a neutral impact on cultural services. This impact is partly positive – this species is the object of scientific research, for example in the context of its migration, determination of place of origin, invasiveness, eradication (Quinteiro et al. 2005, Soroka et al. 2009, Pfenninger et al. 2014, Zemanova et al. 2016 – P). It is used in education – as a relatively large animal, easy to breed and to acquire from its natural state, it is used in teaching biology in schools. On the other hand, it has a negative impact on aesthetic and recreational functions, as it belongs to the pest of many vegetable species, decorative plants, agricultural, orchard and herbal plants, kept by hobbyist (Kozłowski 2005, 2008, 2012, Kozłowski and Kozłowski 2010 – P), it may also evoke fear and revulsion.

A5b | Effect of climate change on the risk assessment of the negative impact of *the species*

Below, each of the Harmonia^{+PL} modules is revisited under the premise of the future climate. The proposed time horizon is the mid-21st century. We suggest taking into account the reports of the Intergovernmental Panel on Climate Change. Specifically, the expected changes in atmospheric variables listed in its 2013 report on the physical science basis may be used for this purpose. The global temperature is expected to rise by 1 to 2°C by 2046-2065.

Note that the answers to these questions are not used in the calculation of the overall risk score, but can be but can be considered when decisions are made about management of *the species*.

a34. INTRODUCTION – Due to climate change, the probability for *the species* to overcome geographical barriers and – if applicable – subsequent barriers of captivity or cultivation in Poland will:

	decrease significantly
	decrease moderately
X	not change
	increase moderately
	increase significantly

aconf30.	Answer provided with a	low **X**	medium	high	level of confidence

acomm34.	Comments: The probability that due to the climate, the Iberian slug will overcome geographical barriers and further barriers related to breeding or cultivating in Poland will not change. This species has a wide range of tolerance to climatic conditions (Slotsbo 2012 – P), as evidenced by its occurrence both in the north and south of Europe, where environmental conditions vary significantly (Rabitsch 2006, Weidema 2006 – P). Egg laying starts in August and can last until December, if the temperature does not drop below 5°C. In the case of climate warming, winters will become milder, the Iberian slug will experience this period better, the time of laying eggs will increase, the percentage of their survival will increase (Stworzewicz and Kozłowski 2012 – P). In turn, the appearance of violent weather phenomena, such as downpours and floods, may limit its spread in the natural environment. A small degree of certainty results from the lack of research on the impact of climate change on the Iberian slug.

a35. ESTABLISHMENT – Due to climate change, the probability for *the species* to overcome barriers that have prevented its survival and reproduction in Poland will:

	decrease significantly
	decrease moderately
X	not change
	increase moderately
	increase significantly

aconf31.	Answer provided with a	low **X**	medium	high	level of confidence

acomm35. Comments:

The likelihood that due to climate changes the Iberian slug will overcome barriers that have prevented it from surviving and reproducing in Poland so far, will not change. At the moment, the Iberian slug is a widespread and domesticated species in the country (Kozłowski and Kornobis 1994, 1995, Kozłowski 1995, 2000a, 2001, 2008, Kozłowski and Sionek 2000, Kozłowski and others 2008 – P). A small degree of certainty results from the lack of research on the impact of climate change on the Iberian slug.

a36. SPREAD – Due to climate change, the probability for *the species* to overcome barriers that have prevented its spread in Poland will:

	decrease significantly
	decrease moderately
X	not change
	increase moderately
	increase significantly

aconf32.	Answer provided with a	low **X**	medium	high	level of confidence

acomm36. Comments:

The likelihood that due to climate changes the Iberian slug will overcome barriers that have prevented it from surviving and reproducing in Poland so far, will not change. The Iberian slug is a widespread species throughout the country (Kozłowski and Kornobis 1994, 1995, Kozłowski 1995, 2000a, 2001, 2008, Kozłowski and Sionek 2000, Kozłowski and others 2008 – P). It occurs in forests and in heavily degraded anthropogenic environments (Proschwitz 1994, Kozłowski 2005a – P). It is also present in agricultural, fruit-growing, herbal, ornamental crops, on plantations where it is a serious threat to cultivated plants (Kozłowski 2010 – P). The spread of this species in Poland does not seem to be related to climate change. A small degree of certainty results from lack of research on the impact of climate change on the Iberian slug.

a37. IMPACT ON THE ENVIRONMENTAL DOMAIN – Due to climate change, the consequences of *the species* on wild animals and plants, habitats and ecosystems in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf33.	Answer provided with a	low **X**	medium	high	level of confidence

acomm37. Comments:

The probability that due to climate changes the impact of the Iberian slug on wild plants and animals, as well as habitats and ecosystems in Poland will increase moderately. It is predicted that as a result of climate change, which will become warmer, the breeding season of the Iberian slug will prolong and the mortality associated with the long winter will drop. Therefore, the number of females is expected to increase, thus increasing the impact of this species on the natural environment. A small degree of certainty of the answer given results from the lack of research on the impact of climate change on the Iberian slug.

a38. IMPACT ON THE CULTIVATED PLANTS DOMAIN – Due to climate change, the consequences of *the species* on cultivated plants and plant domain in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf34.	Answer provided with a	low	medium	high	level of confidence
		X			

acomm38. Comments:

The Iberian slug spreads mainly in plant crops, which seems to have no relation to climate change. In crops it reaches the highest numbers. It is predicted that as a result of climate change, which will become warmer, the breeding season of the Iberian slug will prolong and the mortality associated with the long winter will drop. Therefore, the number of females is expected to increase, thus increasing the impact of this species on arable crops. The slugs are active and feed when it is warm, which further increases the predicted negative impact on plant cultivation. There may be more crop pests with similar preferences, which may compete with the garden slug, but even if its number decreases, the total negative impact of the slug and competitors on arable crops will be increased. Taking all this into account, it can be assumed that the probability of the influence of the Iberian slug on arable crops or plant production in Poland as a result of climate change will increase moderately. A small degree of certainty of the answer given results from the lack of research on the impact of climate change on the Iberian slug.

a39. IMPACT ON THE DOMESTICATED ANIMALS DOMAIN – Due to climate change, the consequences of *the species* on domesticated animals and animal production in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf35.	Answer provided with a	low	medium	high	level of confidence
		X			

acomm39. Comments:

The Iberian slug is a vector and an intermediate host of parasitic nematodes that cause diseases of domestic and farm animals. These diseases are more common in warm climatic zones (e.g. because parasites are not active and do not reproduce at low temperatures or even die), so climate warming may be conducive to increasing the frequency of these diseases in Poland. Locally, the number of the Iberian slugs may increase, and thus the probability of the transmitted parasite may increase. Therefore, it can be assumed that the probability of the influence of the Iberian slug on livestock and domestic animals, as well as animal production in Poland will increase moderately as a result of climate change. A small degree of certainty results from the lack of research on the impact of climate change on the Iberian slug.

a40. IMPACT ON THE HUMAN DOMAIN – Due to climate change, the consequences of *the species* on human in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf36.	Answer provided with a	low **X**	medium	high	level of confidence

acomm40. Comments:

The Iberian slug belongs to the *Arion* genus, in which nematode larvae have been detected that can cause eosinophilic meningitis in humans (Grewal et al 2003 – P). The spread of this disease is related among others to global warming. So far, people's infections have always occurred in warmer climate zones than the one in Poland. A warmer climate can affect the local increase in the number of slugs, and thus increase the probability of this parasite, as well as other pathogens that are transmitted by the slug. Therefore, it can be assumed that with the warming of the climate, the probability of the influence of the Iberian slug on people in Poland will increase moderately. A small degree of certainty of the answer given results from the lack of research on the impact of climate change on the Iberian slug.

a41. IMPACT ON OTHER DOMAINS – Due to climate change, the consequences of *the species* on other domains in Poland will:

	decrease significantly
	decrease moderately
X	not change
	increase moderately
	increase significantly

aconf37.	Answer provided with a	low **X**	medium	high	level of confidence

acomm41. Comments:

There was no significant influence of the Iberian slug on other objects in Poland, and it is not expected that climate change would have such impact. A small degree of certainty results from the lack of research on the impact of climate change on the Iberian slug.

Summary

Module	Score	Confidence
Introduction (questions: a06-a08)	1.00	1.00
Establishment (questions: a09-a10)	1.00	1.00
Spread (questions: a11-a12)	0.88	1.00
Environmental impact (questions: a13-a18)	0.33	0.75
Cultivated plants impact (questions: a19-a23)	0.50	0.83
Domesticated animals impact (questions: a24-a26)	0.42	0.83
Human impact (questions: a27-a29)	0.50	0.75
Other impact (questions: a30)	0.00	0.50
Invasion (questions: a06-a12)	0.96	1.00
Impact (questions: a13-a30)	0.50	0.73
Overall risk score	0.48	
Category of invasiveness	potentially invasive alien species	

A6 | Comments

This assessment is based on information available at the time of its completion. It has to be taken into account. However, that biological invasions are, by definition, very dynamic and unpredictable. This unpredictability includes assessing the consequences of introductions of new alien species and detecting their negative impact. As a result, the assessment of the species may change in time. For this reason it is recommended that it regularly repeated.

acomm42. Comments:

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3. Unpublished data (N)

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4. Other (I)

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5. Author's own data (A)

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