Risk Analysis for *Torymus sinensis*

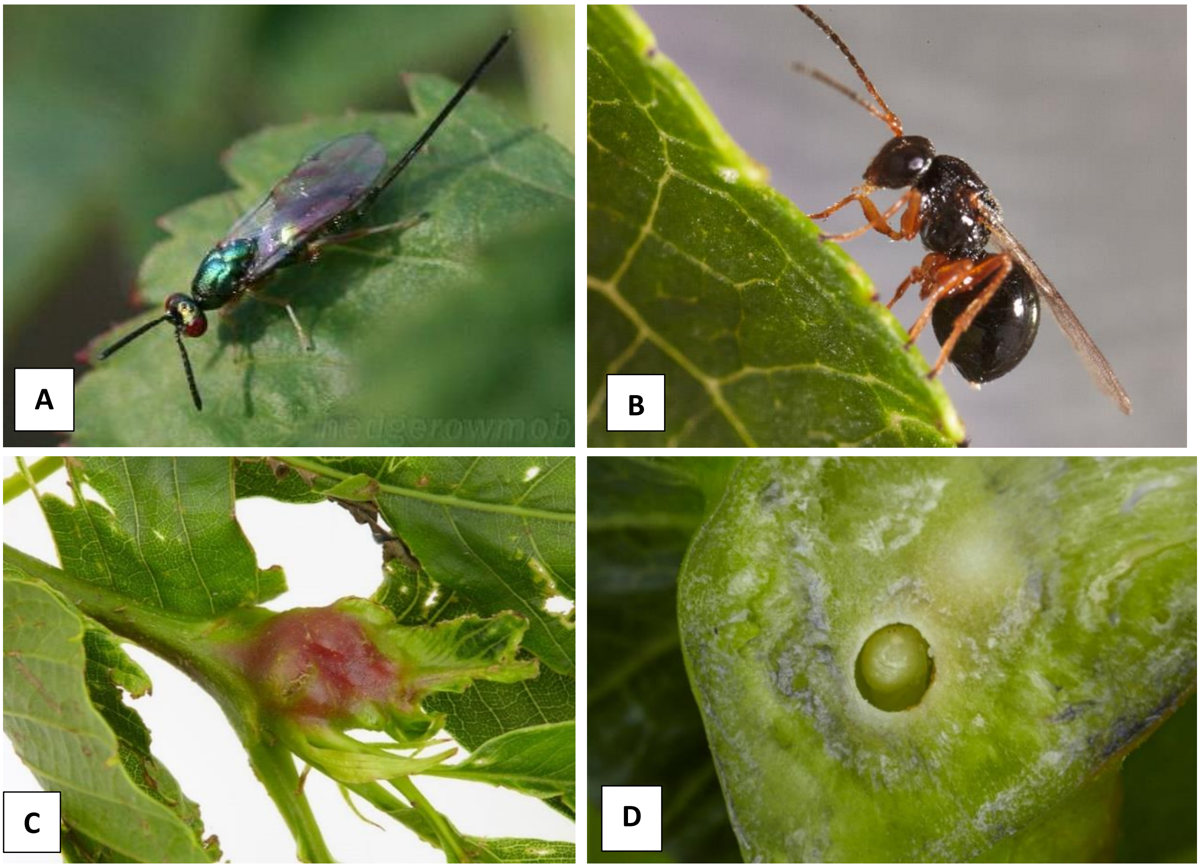

Figure 1. The Biological Control Agent (BCA) *Torymus sinensis* and the Target Organism *Dryocosmus kuriphilus*: **A)** *Torymus sinensis* adult female © http://hedgerowmobile.com; **B)** *Dryocosmus kuriphilus* adult female © Fera; **C)** *Dryocosmus kuriphilus* gall on sweet chestnut in the UK © Fera; **D)** *Dryocosmus kuriphilus* gall cut open to reveal the larva inside a central chamber © Fera

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Figure 2 (opposite page). *Dryocosmus kuriphilus* impact on sweet chestnut at Farningham Wood Nature Reserve, Kent. **A)** Coppiced sweet chestnut with low level of *D. kuriphilus* infestation, showing dense foliage and large leaves © C. Malumphy; **B)** Coppiced sweet chestnut with high level of *D. kuriphilus* infestation. The foliage is sparse, and reduced in size, exposing the stems © C. Malumphy; **C)** Terminal growth with no galls (left) and numerous galls (right) showing smaller and fewer leaves © C. Malumphy; **D)** *D. kuriphilus* gall causing a right-angle bend in the stem © C. Malumphy; **E)** *D. kuriphilus* galls are often reddish before becoming green; **F)** Many *D. kuriphilus* galls coalesce to form large galls and can kill off the terminal growth © C. Malumphy; **G)** High density *D. kuriphilus* galls on the branch apex © D. De Marzo.

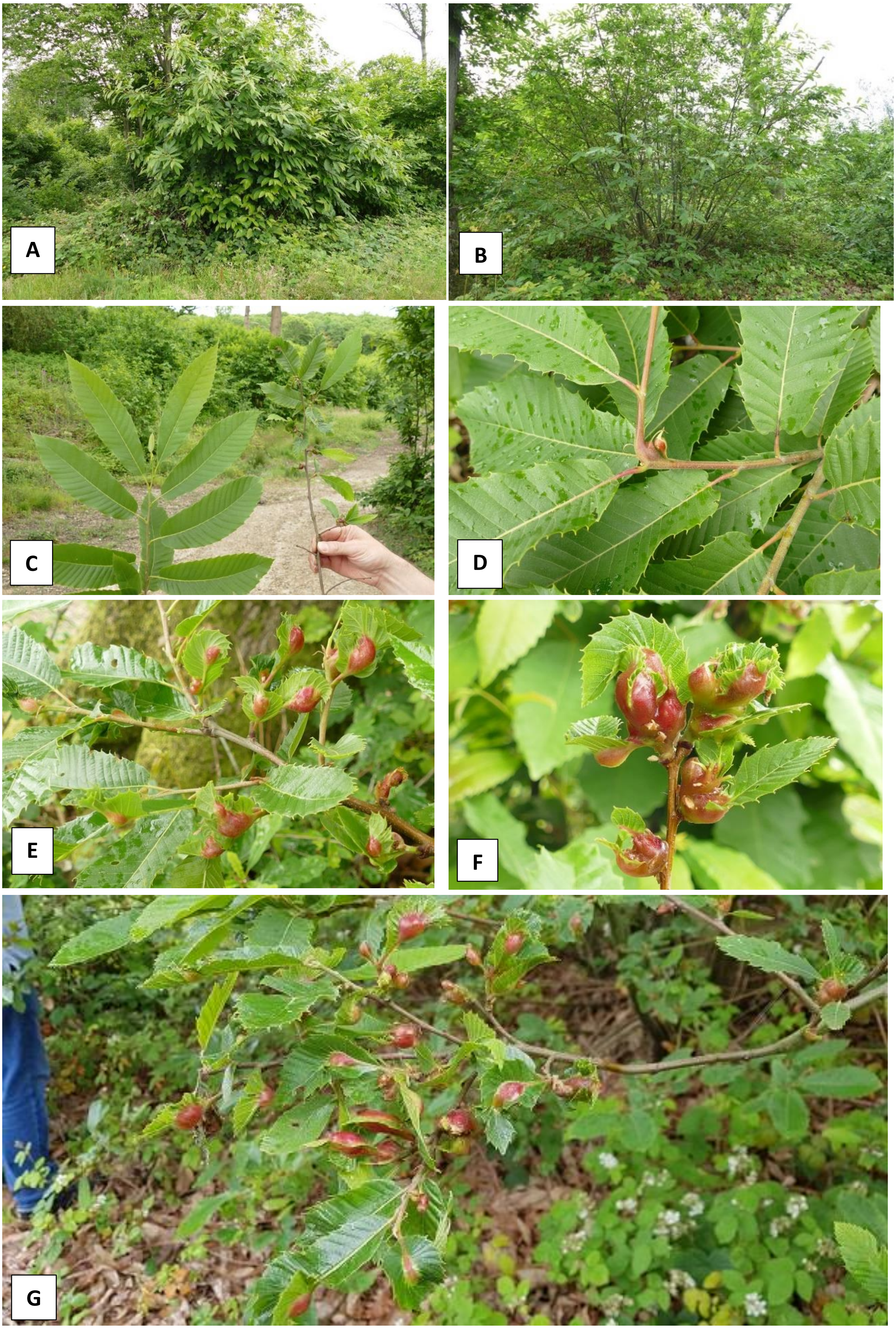

Figure 2. See legend on opposite page

Executive summary

The Oriental chestnut gall wasp *Dryocosmus kuriphilus* (Fig. 1) is the most damaging insect pest of chestnut species (*Castanea* spp.) worldwide. This invasive alien species has established in southern England since at least 2014. Currently *D. kuriphilus* appears to be having a low economic impact in the UK, however, the wasp has only recently been introduced, the gall density at Farningham Wood Nature Reserve has increased rapidly between 2015 and 2019, it is spreading across south-east England (present in an area 134 km from North to South and 102 km from West to East), and the impact may become more significant in the future. In 2019, the gall wasp was observed to have a significant impact on the growth of coppiced sweet chestnut trees at Farningham Wood (see Fig. 2), reducing the area of foliage (smaller and fewer leaves), and the gall density was up to 142 galls/m. The only effective management option is classical biological control using the biological control agent (BCA) *Torymus sinensis* (Fig. 1) (a parasitoid wasp). This method has been used to successfully control *D. kuriphilus* in Croatia, France, Hungary, Italy, Japan, Portugal, Slovenia, Spain, Turkey and the USA. For example, it has proved to be highly successful in northern Italy reducing *D. kuriphilus* infestation rates to almost zero, nine-years after the release of the parasitoid. A Risk Assessment for the BCA has been completed in support of an application for a licence to release *T. sinensis* in England.

This BCA Risk Assessment shows:

Establishment

Climatic modelling indicates it should be possible for *T. sinensis* to establish self-sustaining biocontrol populations in South East England where *D. kuriphilus* occurs. Factors that may interfere with establishment include the relatively low density of sweet chestnut trees, low density of *D. kuriphilus* galls, mortality of *T. sinensis* in galls overwintering on the ground, the effect of climate on synchronization between the gall formation and *T. sinensis* adult emergence, and effects of hyper-parasitism.

Spread

The potential rate of spread of *T. sinensis* in the RA area is expected to be lower than reported in Italy and Japan due to lower spring temperatures when the adults are active, potentially higher winter mortality as a greater proportion of galls fall and overwinter on the ground, much lower gall density in most areas, and lower sweet chestnut density. It is anticipated that *T. sinensis* will have a moderate to high rate of spread with a high degree of uncertainty.

Eradication or containment of the pest and transient populations

Once released and established, there are no practical measures available for the eradication or containment of *T. sinensis*. It is possible that *T. sinensis* will naturally spread across Europe and be introduced into the UK in an unmanaged way.

Economic, Environmental and Social Impacts

There are no expected negative economic or social consequences resulting from the introduction of *T. sinensis*. Suppression of the *D. kuriphilus* populations may have an economic benefit by lowering the risk of the gall wasp reducing foliage area and affecting branch architecture (killing terminal buds causing lateral branching, and causing right-angle bends in stem growth), which is detrimental to the quality of coppice grown for fencing. Adult *D. kuriphilus* emergence holes also provide an entry point for the pathogenic fungus that causes sweet chestnut blight (*Cryphonectria parasitica*) which is regulated in the UK. A reduction in *D. kuriphilus* populations may therefore help mitigate the impact of sweet chestnut blight which has recently been found in England. A Cost Benefit Analysis indicates the release programme provides value for money as the benefits of a recovery in the yield and non-market benefits of sweet chestnut trees outweighs the programmes outlays by a ratio of 0.59.

Torymus sinensis may have some negative environmental impact by parasitizing native oak-galling wasps and there is a small risk of hybridisation with native *Torymus* species. The incidence of *T. sinensis* parasitizing native oak-galling wasps in Italy has been found to be very low (only 0.01% of adult chalcids reared from 14,512 non-target galls were *T. sinensis*) and there are no reported environmental consequences. No evidence of hybridization has been observed in Europe.

Conclusion

The high gall density of *D. kuriphilus* observed in some areas of SE England is having a negative affect on the growth of sweet chestnut and the only effective management option is classical biological control using the BCA *T. sinensis*. The risks and potential negative economic, environmental and social consequences of releasing *T. sinensis* into England are low. It is therefore recommended that the *T. sinensis* is used for the control of *D. kuriphilus* and its establishment, efficacy and environmental impact be monitored. This will provide invaluable data for future potential introductions of BCAs in the UK.

Stage 1: Initiation

The aim of the initiation stage is to identify the Biological Control Agent, state the purpose of the application and the intended area of release

1.01 a. Give the reason for performing the Risk Assessment (RA) on the Biological Control Agent (BCA)

The Oriental chestnut gall wasp *Dryocosmus kuriphilus* (OCGW) is the most damaging insect pest of chestnut species (*Castanea* spp.) worldwide (EPPO, 2005; EFSA, 2010; Down & Audsley, 2016). This alien invasive species has established in southern England since at least 2014, and a detailed review by Down & Audsley (2016) identified classical biological control using the hymenopteran parasitoid *Torymus sinensis* to be the most effective and appropriate management option for the UK. Ferracini *et al*. (2019) published a comprehensive review of the effectiveness of *T. sinensis* and concluded that it proved to be an outstanding biocontrol agent. For example, in Northwest Italy the *D. kuriphilus* infestation rate was nearly zero, nine years after release of the parasitoid with no evidence of resurgence in gall wasp infestation levels.

A Risk Assessment of the BCA is a requirement of the license application needed to obtain approval for the release of *T. sinensis* for the management of *D. kuriphilus* in the UK.

1.02 **a. Name of the BCA** (Fig. 1A)

Kingdom	Animalia
Phylum	Arthropoda
Class	Insecta
Order	Hymenoptera
Super-Family	Chalcidoidea
Family	Torymidae
Genus	*Torymus*
Species	*sinensis*
Authority	Kamijo, 1982
Common name	None

Name of the target organism (Fig. 1B-D)

Kingdom	Animalia
Phylum	Arthropoda
Class	Insecta
Order	Hymenoptera
Super-Family	Chalcidoidea
Family	Cynipidae
Genus	*Dryocosmus*

Species	*kuriphilus*
Authority	Yasumatsu, 1951
Common names	Oriental chestnut gall wasp (preferred name), Asian chestnut gall wasp, Chestnut gall wasp

1.02 b. Indicate the type of Biological Control Agent and where it will be obtained

The BCA is classed as a Non-Native Biological Control Agent (NNBCA) and/or an Invertebrate Biological Control Agent (IBCA). It is a parasitoid wasp in the superfamily Chalcidoidea (full taxonomy is provided in section 1.02a). The BCA will be obtained from specimens collected in the field and cultured in Northern Italy.

ID confirmation

Authority (determined by)	Dr Chiara Ferracini, Dipartimento di Scienze Agrarie, Forestali e Alimentari (DISAFA), Largo Paolo Braccini 2, 10095 Grugliasco (Torino) ITALY tel. + 39 011 6708700- fax + 39 011 6708535
Methodology	There are molecular (Colombari *et al*., 2016) and morphological methods available for the identification of *Torymus sinensis*. The standard morphological method used is an unpublished key (continually evolving as new species are found in Europe) written by Dr R. R. Askew (Manchester, UK) and Dr C. Thúroczy (Budapest, Hungary), which has been widely used for decades in the research of parasitoid communities of oak gall wasps. Another key reference for the identification of *Torymus* species in Europe is by Graham & Gijswijt (1998). The identity of the specimens will also be confirmed in the UK both molecularly and morphologically at Fera Science Ltd. and by Prof. Graham Stone at the University of Edinburgh.
Voucher deposits	Voucher specimens have been deposited in the invertebrate reference collections of Fera Science Ltd.

Characterization of the BCA

Specify life-stages, strains or taxonomic constraints

Taxonomic characteristics	Strains of *T. sinensis* have been recorded that differ in their ecology, such as timing of adult emergence (Murakami *et al*., 1995). The strain or 'ecological type' established in Europe is referred to as the Chinese strain due to its origin.

Origin and distribution of the BCA

What is the immediate source of the organism? Include details of the origin and distribution of the BCA (species or lower taxon)

Origin	*Torymus sinensis* is non-indigenous to Great Britain and will be obtained from northern Italy
Field collected	The OCGW galls are field collected in Northern Italy and adult *Torymus sinensis* reared in a laboratory
Laboratory culture	*Torymus sinensis* is not cultured (only reared) in a laboratory
Producer/Supplier	Green Wood Service Srl http://www.greenwoodservicesrl.com/?lang=en There is a possibility that we may obtain the BCA directly from Dr Chiara Ferracini – contact details above There is also a Spanish company Agrobio that may be used if the above cannot supply enough wasps at the appropriate time https://www.agrobio.es/products/pest-control/torycontrol-torymus-sinensis-control-chestnut-gall-wasp/?lang=en
Original area and distribution	*Torymus sinensis* is native to China but was deliberately introduced to Italy in 2005
Areas introduced before	Croatia, France, Hungary, Italy, Japan, Portugal, Slovenia, Spain, Turkey and the USA (Ferracini *et al*., 2019). It has apparently also spread naturally from Italy across Slovenia to Croatia and Hungary (Matoševi *et al*., 2017), and from France into Spain (Nieves-Aldrey *et al*., 2019).

Product information

Product information	
Product/Trade name	*Torymus sinensis*
Producer/Supplier	Green Wood Service Srl: http://www.greenwoodservicesrl.com/?lang=en There is a possibility that we may obtain the BCA directly from Dr Chiara Ferracini – contact details above There is also a Spanish company Agrobio that may be used if the above cannot supply enough wasps at the appropriate time

	https://www.agrobio.es/products/pest-control/torycontrol-torymus-sinensis-control-chestnut-gall-wasp/?lang=en
Method of supply	Plastic tubes each containing 100-120 females and 50-60 males.
Life stages	Adults
Label information	Unknown
Storage	Quarantine licenced facility at Fera Science Ltd., Sand Hutton, York, YO41 1LZ
Method of use	Single release (100-120 females and 50-60 males) at approximately 20-40 sites in and around London where OCGW has been detected. This does depend on availability of the parasitoid wasps.
Product composition	
Co-formulants	None
Contaminants	None

1.03 Clearly define the RA area.

The RA area is the area in the UK where *D. kuriphilus* has the potential to establish, which is restricted by the distribution of its only host, sweet chestnut *Castanea sativa* Mill. (Fagaceae).

In Great Britain, sweet chestnut comprises around 3% of the standing volume of broadleaved trees, with the majority of this being privately owned (Forestry Commission, 2013). Within the UK, over 98% of sweet chestnut is found in England (Forestry Commission, 2013), while over 90% of sweet chestnut coppice stands in England are in South-East England (Braden and Russell, 2011) in the following English counties: Bedfordshire, Berkshire, Buckinghamshire, East Sussex, Hertfordshire, Greater London, Hampshire, Isle of White, Kent, Oxfordshire, Surrey and West Sussex. There are approximately 22 thousand ha of sweet chestnut in South East England.

1.04 Does a relevant earlier RA exist?

No RA exists for *Torymus sinensis* with respect to the UK. There is a published evaluation of the use of *Torymus sinensis* as a BCA in Switzerland (Aebi *et al.*, 2011) and there are publications that address the risk of using *T. sinensis* for biological control in Europe (EFSA, 2010; Gibbs *et al.*, 2011). However, these publications are now out-of-date as there have been many research papers published on *D. kuriphilus* and *T. sinensis* since.

1.05 Specify all host species. Indicate the ones which are present in the RA area.

Note: the taxonomic level at which hosts are considered should normally be the species. The use of higher or lower taxonomic levels should be scientifically justified. The BCA should be able to complete its life cycle or multiply on the hosts considered. Some other species might also prove to be suitable hosts in the absence of the usual host species. Additionally, it may be appropriate to distinguish between major and minor hosts when answering this question. If the PRA is conducted on a BCA which is indirectly injurious to species through effects on other organisms, these organisms should also be present in the RA area. Habitats may be considered according to the CORINE land cover classification. It may be useful to consider associations with key-stone or dominant species. For intentionally introduced organisms, indicate the intended and unintended habitats.

All of the hosts of *T. sinensis* are gall-forming wasps assigned to the family Cynipidae in the order Hymenoptera. All the oak-gall wasps in the UK have an asexual and sexual generation that induce distinct types of galls, hence some species have two common names.

Preferred host

Dryocosmus kuriphilus Yasumatsu – Oriental chestnut gall wasp
This invasive gall wasp was first detected in the UK in 2015 although it is likely to have been present for several years before that. It has since been detected at 140+ locations (woodland, parks, roadside trees) in rural and urban areas in South-East England. It has spread across an area of 134 km North to South and 102 km West to East (including Bedfordshire, Berkshire, Essex, Greater London, Hampshire, Hertfordshire, Kent, Surrey). It is highly specialised and only forms galls on sweet chestnut, *Castanea sativa*, which is an introduced tree in the UK, grown as an ornamental and for coppicing. There are no other species of wasp that form galls on sweet chestnut in Europe. *Dryocosmus kuriphilus* is having a limited negative impact on sweet chestnut tree growth in the UK.

Non-preferred hosts observed in the wild that are present in the UK

Quacchia *et al.* (2014) exposed galls of the following native species to adult female *T. sinensis* in petri dishes in a laboratory to see if they would oviposit in non-preferred (alternative) hosts: *Andricus crispator* Tschek, *A. curvator* Hartig, *A. cydoniae* Giraud, *A. grossulariae* Giraud, *A. multiplicatus* Giraud, *Biorhiza pallida* Olivier and *Dryocosmus cerriphilus* Giraud. The native galls were dissected open and no *T. sinensis* eggs were found.

Torymus sinensis has been reared from 10 different species of oak-gall wasp collected in the wild in Italy (Ferracini *et al*., 2015 and 2017) that are present in the UK (see Table 1). This does not mean that these species would necessarily be suitable hosts in the UK due to differences in phenology. Oak galls often develop about a month later in the UK compared with Italy due to climatic differences and they may not be synchronised with adult *T. sinensis* flight period.

Table 1. Non-preferred hosts for *Torymus sinensis* observed in the wild that are present in the UK

Non-preferred cynipid host	**Distribution in continental Europe**	**Distribution in UK**	**Host plants**
Andricus curvator Hartig, 1840 – Curved leaf gall-causer, Collared-bud Gall Causer	Widespread	Widespread, common	section *Quercus* oaks
Andricus cydoniae Giraud, 1859	Limited to central and southern Europe	Introduced	section Cerris oaks
Andricus inflator Hartig, 1840	Widespread	Widespread, common	section *Quercus* oaks
Andricus kollari (Hartig, 1843) – Marble gall	Widespread	Widespread, common	section *Quercus* oaks
Andricus lignicolus (Hartig, 1840) – Cola-nut gall	Widespread	Widespread, common	*Quercus robur, Q. petraea*
Andricus lucidus (Hartig, 1843) – Hedgehog gall	Widespread	Rare	section *Quercus* oaks
Biorhiza pallida (Olivier, 1791)	Widespread	Widespread, common	section *Quercus* oaks
Cynips quercusfolii Linnaeus, 1758 – Cherry gall	Widespread	Widespread, common	section *Quercus* oaks
Neuroterus anthracinus (Curtis, 1838) – Oyster gall	Widespread	Widespread, common	section *Quercus* oaks
Neuroterus quercusbaccarum (Linnaeus, 1758) – Currant gall, Common spangle gall	Widespread	Widespread, common	section *Quercus* oaks

Non-preferred cynipid host	**Distribution in continental Europe**	**Distribution in UK**	**Host plants**
Andricus curvator Hartig, 1840 – Curved leaf gall-causer, Collared-bud Gall Causer	Widespread	Widespread, common	*Quercus* spp.
Andricus cydoniae Giraud, 1859 [NB Not confirmed from the UK, G. Stone pers. comm.]	Limited to central and southern Europe	Introduced	*Quercus* spp.

Andricus inflator Hartig, 1840	Widespread	Widespread, common	*Quercus* spp.
Andricus kollari (Hartig, 1843) – Marble gall	Widespread	Widespread, common	*Quercus* spp.
Andricus lignicolus (Hartig, 1840) – Cola-nut gall	Widespread	Widespread, common	*Quercus robur, Q. petraea*
Andricus lucidus (Hartig, 1843) – Hedgehog gall	Widespread	Rare	*Quercus* spp.
Biorhiza pallida (Olivier, 1791)	Widespread	Widespread, common	*Quercus* spp.
Cynips quercusfolii Linnaeus, 1758 – Cherry gall	Widespread	Widespread, common	*Quercus* spp.
Neuroterus anthracinus (Curtis, 1838) – Oyster gall	Widespread	Widespread, common	*Quercus* spp.
Neuroterus quercusbaccarum (Linnaeus, 1758) – Currant gall, Common spangle gall	Widespread	Widespread, common	*Quercus* spp.

Non-preferred host only observed in the laboratory that is present in the UK

Andricus grossulariae Giraud, 1859
Widely distributed across Europe, including the UK. Develops on oak (*Quercus* spp.).

Non-preferred hosts observed in the wild that are absent from the UK

Torymus sinensis has been reared from 5 additional different species of oak gall wasp collected in the wild in Italy (Ferracini *et al*., 2015 and 2017) that are absent from the UK (see Table 2).

Table 2. Non-preferred hosts for *Torymus sinensis* observed in the wild that are absent in the UK

Non-preferred cynipid host	**Distribution in continental Europe**	**Distribution in UK**	**Host plants**
Andricus caputmedusae (Hartig, 1843)	Widespread	Absent	*Quercus* spp.
Andricus coronatus (Giraud, 1859)	Widespread	Absent	*Quercus* spp.
Andricus dentimitratus (Rejto, 1887)	Widespread across southern Europe	Absent	*Quercus* spp.

Andricus quercustozae (Bosc, 1792)	Widespread across southern Europe	Absent	*Quercus* spp.
Synophrus politus Hartig, 1843	Widespread across southern Europe	Absent	*Quercus* spp.

Native and established cynipid galls found in the UK that are potential non-preferred hosts

Graham Stone, Professor of Ecology at Edinburgh University, international specialist in gall wasps and their parasitoids, contributed most of the data presented in this section regarding the suitability of cynipid galls in the UK as potential non-preferred hosts for *T. sinensis*.

The main criteria used to determine the suitability of cynipid galls as potential hosts were:

- Synchronization (phenological overlap)

Is the gall of either the sexual or asexual generation available (month it matures) during the flight period (April to May/June) of adult female *T. sinensis*?

- Host resource suitability

Is the host larva large enough for successful parasitoid development?

- Gall accessibility

Some galls, for example those developing on roots, are unlikely to be accessible to adult *T. sinensis*. For example, the asexual generations of *Andricus quercusradicis* (Fabricius) and *Biorhiza pallida* (Olivier).

A precautionary approach has been taken resulting in a longer list of potential hosts than may naturally occur in the wild. For example, the native parasitoids and *T. sinensis* may have poor synchronization in most years but have been included if there is an occasional phenological overlap. The larva of many potential host species, may only occasionally be large enough to provide sufficient resource for successful parasitoid development. A small host larva will result in a smaller adult parasitoid with reduced fecundity and longevity. There is therefore a high degree of uncertainty regarding the species of potential host selected using these criteria.

Table 3 lists the UK oak-feeding cynipids, the month the gall of both sexual and asexual generations matures, synchronization of the gall and flight activity of adult *T. sinensis*, vulnerability given the timing and resource availability, and comments such as the reasons why a species may not be a suitable host and gall location. The species that are considered suitable as potential alternative hosts are highlighted in yellow.

This method has resulted in 24 species identified as potential hosts in the UK. Ten of these have already been recorded as hosts in Italy and Ferracini *et al*. (2017) reared parasitoids from the galls of a further four species (*Andricus foecundatrix* (Hartig); *Cynips disticha* Hartig*; C.*

divisa Hartig; and *Neuroterus albipes* (Schenck)) but found no evidence of *T. sinensis*. This leaves the following 10 species: *Andricus corruptrix* (Schlechtendal); *A. paradoxus* (Radoszkowski); *A. quadrilineatus* Hartig; *A. rhyzomae* (Hartig); *A. seminationis* (Giraud); *Cynips longiventris* Hartig; *Neuroterus politus* Hartig; *N. tricolor* (Hartig); *Pseudoeuroterus saliens* (Kollar); and *Trigonaspis megaptera* (Panzer).

Should each of these 10 species be tested as potential hosts for *T. sinensis*?

Some laboratory based tests have given different results compared to wild collected galls. Quacchia *et al.* (2014) found *Andricus curvator, Andricus cydoniae* and *Biorhiza pallida* unsuitable as hosts whereas Ferracini *et al*. (2017) reared *T. sinensis* from all three species. Ferracini *et al*. (2017) also observed successful oviposition in the laboratory by T. sinensis in the asexual generation galls of *A. cydoniae*, *A. grossulariae* and *A. lucidus*.

The published evidence (e.g. incidence of parasitism of non-preferred hosts in Italy) suggests that *T. sinensis* is very host specific and rates of parasitism of these potential native species is likely to be extremely low to negligible (only 0.01% of adult chalcids reared from 14,512 non-target galls were *T. sinensis*). Therefore, laboratory testing of these 10-additional species as potential hosts is unlikely to produce meaningful results and collecting sufficient galls in the wild where *T. sinensis* is already established in Europe could take several years, and again is unlikely to produce meaningful results due to differences in climatic conditions and phenology. *Torymus sinensis* is highly likely to continue its host range expansion in Europe, but at levels that are likely to have a minimal impact with no changes in the distribution or abundance of non-preferred hosts expected.

Table 3 Potential non-preferred hosts for *Torymus sinensis* present in the UK

Generation: A = Asexual; S = Sexual.

Gall wasp species	Generation	Month gall matures	Synchronisation	Vulnerability given timing + resource	Comments (reason why it's not a suitable host and location of gall)
Andricus aries (Giraud)	A	Aug		N	Probably develops too late in the year. Buds of *Q. petraea/robur*
Andricus callidoma (Hartig)	S	May	Y	N	Galls too small. May not have enough resource for parasitoid development. Galls on catkins.
Andricus callidoma	A	Aug		N	Probably develops too late in the year. Buds of *Q. petraea/robur*
Andricus corruptrix (Schlechtendal)	S	May	Y	N	May be too small for parasitoid development. Catkins of *Q. cerris*
Andricus corruptrix	A	July	Y	Y	Possible host. Buds of *Q. petraea/robur*

Andricus curvator (Hartig)	S	Jun-Jul	Y	Y	Probable host (host in Italy). Leaves of *Q. petraea/robur*
Andricus curvator	A	Sep		N	Probably develops too late in the year. Buds of *Q. petraea/robur*
Andricus foecundatrix (Hartig)	S	May	Y	N	Probably too small for successful parasitoid development. Small galls on catkins.
Andricus foecundatrix	A	Jul	Y	Y	Possible host but may develop too late. Buds of *Q. petraea/robur*
Andricus glandulae (Hartig)	S	Jun	Y	N	Probably too small for successful parasitoid development. Small galls on catkins.
Andricus glandulae	A	Sep		N	Probably develops too late in the year. Buds of *Q. petraea/robur*
Andricus grossulariae (Giraud)	S	May	Y	Y	Probable host (laboratory host in Italy). Catkins of *Q. cerris*
Andricus grossulariae	A	Sep		N	Probably develops too late in the year. Acorns/buds of *Q. petraea/robur*
Andricus inflator (Hartig)	S	Jun-Jul	Y	Y	Probable host (host in Italy). Buds of *Q. petraea/robur*
A. inflator	A	Sep		N	Probably develops too late in the year. Buds of *Q. petraea/robur*
Andricus kollari (Hartig)	S	May	Y	Y	Relatively small for parasitoid development (host in Italy). Buds of *Q. cerris*
Andricus kollari	A	Aug-Sep		N	Probably develops too late in the year. Buds of *Q. petraea/robur*
Andricus lignicolus (Hartig)	S	May	Y	Y	Relatively small for parasitoid development (host in Italy). Buds of *Q. cerris.*

Table 3 continued

Gall wasp species	Generation	Month gall matures	Synchronisation	Vulnerability given timing + resource	Comments (reason why it's not a suitable host and location of gall)
Andricus. lignicolus	A	Aug-Sep		N	Probably too late in the year. Buds of *Q. petraea/robur*
Andricus lucidus (Hartig)	S	May	Y	Y	Relatively small for parasitoid development (host in Italy). Catkins of *Q. cerris*
Andricus lucidus	A	Aug-Sep		N	Probably develops too late in the year Buds/acorns of petraea/robur
Andricus malpighii (Alder)	S	May	Y	N	Probably too small for successful parasitoid development. Catkins of petraea/robur
Andricus malpighii	A	Aug-Sep		N	Probably develops too late in the year.

Andricus paradoxus (Radoszkowski)	A	Jun		Y	Possible host. Rare in UK. Buds of *Q. petraea/robur*
Andricus quadrilineatus (Hartig)	S	May		N	Probably too small for successful parasitoid development. Catkins of *Q. petraea/robur*
Andricus. quadrilineatus	A	May-Jun	Y	Y	Possible host but maybe too small for parasitoid development. Catkins/leaves of *Q. petraea/robur*
Andricus quercuscalicis (Burgsdorf)	S	May	Y	N	Probably too small for successful parasitoid development. Catkins of *Q. cerris*.
Andricus quercuscalicis	A	Sep		N	Probably develops too late in the year. Acorns of *Q. petraea/robur*.
Andricus quercuscorticis (L.)	S	May	Y	N	Probably too small for successful parasitoid development. Buds of *Q. petraea/robur*
Andricus quercuscorticis	A	Sep		N	Probably develops too late in the year. Shoots of *Q. petraea/robur*
Andricus quercusradicis (Fabricius)	S	Sep		N	Probably too small for successful parasitoid development. Cryptic galls in shoots of *Q. petraea/robur*.
Andricus quercusradicis	A	Sep		N	Probably inaccessible as galls form on roots of *Q. petraea/robur*
Andricus quercusramuli (L.)	S	May-Jun	Y	N	Probably too small for successful parasitoid development. Catkins of *Q. petraea/robur*
Andricus quercusramuli	A	Sep		N	Probably develops too late in the year. Buds of *Q. petraea/robur*
Andricus rhyzomae (Hartig)	S	Jul	Y	N	Probably too small for successful parasitoid development. Leaves of *Q. petraea/robur*
Andricus. rhyzomae	A	Sep		Y	Possible host. Galls take 2 years to develop on shoots of *Q. petraea/robur,* so they are present for a long period

Table 3 continued

Gall wasp species	Generation	Month gall matures	Synchronisation	Vulnerability given timing + resource	Comments (reason why it's not a suitable host and location of gall)
Andricus seminationis (Giraud)	A	May-Jun	Y	Y	Possible host. Rare in the UK. Catkins of *Q. petraea/robur*
Andricus solitaries (Fonscolombe)	S	May	Y	N	Probably too small for successful parasitoid development. Catkins of *Q. petraea/robur*
Andricus solitarius	A	Sep		N	Probably develops too late in the year. Buds of *Q. petraea/robur*
Aphelonyx cerricola (Giraud)	A	Sep		N	Probably develops too late in the year. Buds of *Q. cerris*
Biorhiza pallida (Olivier)	S	May-Jun	Y	Y	Probable host (host in Italy). Buds of *Q. petraea/robur*

Biorhiza. pallida	A	Oct		N	Probably develops too late in the year and inaccessible. Roots of *Q. petraea/robur*
Callirhytis species	S	Jun	Y	N	Probably too small for successful parasitoid development. Cryptic galls in stems of *Q. cerris/petraea/robur*
Callirhytis species	A	Nov		N	Probably develops too late in the year cryptic galls in acorns of *Q. cerris/petraea/robur*
Cynips agama (Hartig)	A	Aug-Sep		N	Probably develops too late in the year. Leaves of *Q. petraea/robur*
Cynips disticha (Hartig)	S	May-Jun	Y	Y	Possible host but maybe too small for successful parasitoid development. Leaves of *Q. petraea/robur*
Cynips disticha	A	Sep		N	Probably develops too late in the year. Leaves of *Q. petraea/robur*
Cynips divisa (Hartig)	S	May-Jun	Y	Y	Possible host but maybe too small for successful parasitoid development. Leaves of *Q. petraea/robur*
Cynips divisa	A	Sep		N	Probably develops too late in the year. Leaves of *Q. petraea/robur*
Cynips longiventris (Hartig)	S	May-Jun	Y	Y	Possible host but maybe too small for successful parasitoid development. Buds of *Q. petraea/robur*
Cynips longiventris	A	Sept		N	Probably develops too late in the year. Buds of *Q. petraea/robur*
Cynips quercusfolii (L.)	S	May-Jun	Y	Y	Relatively small for parasitoid development (host in Italy). Buds of *Q. petraea/robur*
Cynips quercusfolii	A	Sep		N	Probably develops too late in the year. Buds of *Q. petraea/robur*
Neuroterus albipes (Schenck)	S	May	Y	Y	Possible host but maybe too small for successful parasitoid development. Leaves of *Q. petraea/robur*

Table 3 continued

Gall wasp species	Generation	Month gall matures	Synchronisation	Vulnerability given timing + resource	Comments (reason why it's not a suitable host and location of gall)
Neuroterus albipes	A	Oct		N	Probably develops too late in the year. Leaves of *Q. petraea/robur*
Neuroterus anthracinus (Curtis)	S	May	Y	Y	Relatively small for parasitoid develop (host in Italy). Leaves of *Q. petraea/robur*
Neuroterus anthracinus	A	Sep		N	Probably develops too late in the year. Leaves of *Q. petraea/robur*
Neuroterus politus (Hartig)	S	Apr-May	Y	Y	Possible host but maybe too small for successful parasitoid development. Buds of *Q. petraea/robur*

Neuroterus politus	A	May-Jun	Y	Y	Possible host. Catkins of *Q. petraea/robur*
Neuroterus numismalis (Geoffroy in Fourcroy)	S	May-Jun	Y	N	Probably too small for successful parasitoid development. Leaves of *Q. petraea/robur*
Neuroterus numismalis	A	Oct		N	Probably develops too late in the year. Leaves of *Q. petraea/robur*
Neuroterus quercusbaccarum (L.)	S	May-Jun	Y	Y	Probable host (host in Italy). Leaves/Catkins of *Q. petraea/robur*
Neuroterus quercusbaccarum	A	Oct		N	Probably develops too late in the year. Leaves of *Q. petraea/robur*
Pseudoeuroterus saliens (Kollar)	S	May-Jun	Y	Y	Possible host. Acorns of *Q. cerris.*
Pseudoeuroterus saliens	A	Oct		N	Probably develops too late in the year. Shoots of *Q. cerris*
Neuroterus tricolor (Hartig)	S	May	Y	Y	Possible host. Leaves of *Q. petraea/robur*
Neuroterus tricolor	A	Oct		N	Probably develops too late in the year. Leaves of *Q. petraea/robur*
Trigonaspis megaptera (Panzer)	S	May	Y	Y	Possible host. Stems of *Q. petraea/robur*
Trigonaspis megaptera	A	Oct		N	Probably develops too late in the year. Leaves of *Q. petraea/robur*

Intended and unintended habitats

The intended habitats (RA area) are any habitats where sweet chestnut trees are found and where *D. kuriphilus* has the potential to establish. The unintended habitats are areas where sweet chestnut trees do not occur. *Torymus sinensis* has the potential to parasitize native oak gall-forming wasps and may therefore occur in unintended areas with oak trees.

1.06 Specify the BCA distribution

Geographical distribution

Torymus sinensis is native to China and has been recorded from Korea and Nepal. It has been deliberately introduced to Croatia, France, Hungary, Italy, Japan, Portugal, Slovenia, Spain, Turkey and the USA (Borowiec *et al*., 2014; Ferracini *et al*., 2019; İpekdal *et al*., 2017; Matošević et al. 2014; Nieves-Aldrey *et al*., 2019; Pérez-Otero *et al*., 2017; Associação Portuguesa da Castanha, 2015).

The spread of *T. sinensis* has been studied in areas where it has been deliberately released but has not been studied in detail elsewhere. It is expected to follow the range expansion of *D. kuriphilus*. The distribution of *D. kuriphilus* has been studied in much greater detail and is better known due to the conspicuous galls it induces. In Europe, *D. kuriphilus* has been recorded from the following countries (listed in order of the first reports) Italy, France, Slovenia, the Netherlands, Switzerland, Hungary, Croatia, Spain, the Czech Republic, Germany, Austria, Portugal, Greece, Turkey, the UK and Romania (Everatt, 2015; Down & Audsley, 2016; Radócz *et al*., 2016).

Stage 2: BCA Risk Assessment

Section A: BCA categorization

At the outset, it may not be clear which insect identified in Stage 1 require(s) a RA. The categorization process examines for each insect whether the criteria in the definition for a quarantine pest are satisfied. In the evaluation of a pathway associated with a commodity, many individual RAs may be necessary for the various insects potentially associated with the pathway. The opportunity to eliminate an organism or organisms from consideration before in-depth examination is undertaken is a valuable characteristic of the categorization process.

An advantage of the categorization process is that it can be done with relatively little information; however, information should be sufficient to adequately carry out the categorization.

There is no need to answer these questions in cases where it is clear from the outset that a full Risk Assessment is required.

Identify the BCA

The identity of the BCA should be clearly defined to ensure that the assessment is being performed on a distinct organism, and that biological and other information used in the assessment is relevant to the organism in question. If this is not possible because the causal agent of particular symptoms has not yet been fully identified, then it should have been shown to produce consistent symptoms and to be transmissible.

2.01 Is the organism clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?

Note: The taxonomic unit for the BCA is generally the species. The use of a higher or lower taxonomic level should be supported by a scientifically sound rationale. In the case of levels below the species, this should include evidence demonstrating that factors such as differences in virulence, host range or vector relationships are significant enough to affect phytosanitary status.

Torymus sinensis Kamijo is a clearly-defined single taxonomic entity that can be adequately distinguished from other entities of the same rank using morphological and molecular characteristics. The full taxonomy is presented in section 1.02a.

2.02 Summarise the biology and ecology of the Biological Control Agent

Torymus sinensis is a sexually reproductive, ectoparasitoid of *D. kuriphilus*. Adult *T. sinensis* emerge in the early spring, mate and females oviposit inside the developing galls onto the surface of the gall wasp larvae. The *T. sinensis* larva feeds on the gall former and remains in the gall until the following spring. *Torymus sinensis* is reported to be univoltine. However, in North-West Italy it exhibits a prolonged diapause, mainly as a late instar larva (Picciau *et al*., 2017), which extends for 12 months, and adults emerge in April as usual, showing a two-year life cycle. The extended diapause plays an important role for the establishment of *T. sinensis* especially in the first years after its release. The factors that trigger this response are unclear.

Graziosi & Rieske (2013) demonstrated that both visual and olfactory cues are required to enable *T. sinensis* to successfully find suitable hosts.

Adult *T. sinensis* wasps are winged and their principal mode of natural dispersal is flight. The preferred host is *D. kuriphilus* although there is increasing evidence that they will occasionally attack oak-galling cynipid wasps. For example, *T. sinensis* has been reared from 15 different species of oak galls collected in the wild in Italy (Ferracini *et al*., 2015 and 2017). However, despite the host-range expansion by *T. sinensis* in Italy, no impact on the distribution or abundance of non-target hosts was detected or expected (Ferracini *et al*., 2017).

Torymus sinensis is not known to present any risk to crops and wild plants in the UK.

There are several species of potential natural enemy for *T. sinensis* in the UK. These are other species of parasitic wasp larvae that attack both gall forming wasps and their parasitoids (hyper-parasitism).

In Japan, laboratory studies indicate that the introduced parasitoid *T. sinensis* is able to mate with the indigenous *T. beneficus* resulting in morphologically intermediate, fertile female offspring (Moriya *et al*., 2003). Analysis of the malic enzyme genotype (Toda *et al*., 2000) suggested that although low levels of hybridization could occur in natural conditions, this was rare. The reliability of this method was put in doubt when Yara *et al.* (2000) were unable to demonstrate that morphologically intermediate individuals were hybrids; it was thought that this method only identifies hybrids between *T. sinensis* and early spring strain *T. beneficus* leaving *T. sinensis*/late spring strain *T. beneficus* unidentified (Yara *et al*., 2000). More recent work analysing molecular markers has shown that the number of *T. sinensis/T. beneficus* (late spring strain) hybrids in the field is now increasing, reaching 22% in 1996 (Yara *et al*., 2010) but that hybridization between *T. sinensis* and the early-spring strain of *T. beneficus* is at a much lower frequency (less than 1%; Yara, 2014). Both strains of the indigenous *T. beneficus* (Murakami, 1988) have been displaced by *T. sinensis* (Yara, 2014). In the case of the late-spring strain this can be explained by hybridization. However, this is not the cause for the displacement of the early-spring strain (Yara *et al.*, 2007, 2010). It has been suggested that this could be due to the higher reproductive ability of *T. sinensis* because *T. sinensis* can oviposit a greater number of eggs and, due to its longer ovipositor, can attack larger galls more efficiently (Moriya *et al.*, 2003; Piao and Moriya 1992; Yara *et al.*, 2007). Displacement of native parasitoid species is unlikely to happen in the UK because no native species rely on *D. kuriphilus* as their main host.

What is the likelihood of hybridisation between *Torymus* species native to the UK and *T. sinensis*? There are more than 50 species of *Torymus* recorded in the UK (Fitton *et al*., 1978); some are morphologically cryptic and can only be identified accurately by sequencing. Quacchia *et al.* (2014) studied potential hybridisation using behavioural experiments and confirmed high levels of mating specificity which suggests that interbreeding with native *Torymus* species is highly unlikely. The mating behaviour consists of a sequence of stereotyped and species-specific behavioural steps. The natural mating behaviour of *T. sinensis* involves a "dance" with the male approaching the female with shaking wings and swaying of the body. No behaviour that indicates species recognition or attempted mating was recorded using *T. sinensis* males and native *Torymus* females (or vice versa) either in trials with individuals or with small groups.

There appears to be no detailed phylogenetic study of the relationships between all the *Torymus* species found in the UK and *T. sinensis* which could indicate which species are most likely to hybridise.

<u>**Determining whether the organism is a plant pest**</u>

2.03 Is the organism in its area of current distribution a known pest (or vector of a pest) of plants or plant products?

No.

2.04 Does the organism have intrinsic attributes that indicate that it could cause significant harm to plants?

> Note: Some organisms may not be known to be harmful in their area of current distribution, but may nevertheless have the potential to become pests in the PRA area. This possibility may have to be considered in certain circumstances.

No.

<u>**Presence or absence in the PRA area and regulatory status (pest status)**</u>

2.05 Does the BCA occur in the PRA area?

> Note: occurrence: the presence in an area of an organism officially recognized to be indigenous or introduced and/or not officially reported to have been eradicated [FAO, 1990; revised FAO, 1995; formerly occurred]. This includes organisms which have been introduced intentionally and which are not subject to containment (notably cultivated plants). Organisms present for scientific purposes under adequate confinement (e.g. in botanic gardens) are not included.

No.

2.06 Is the BCA widely distributed in the PRA area?

> Note: a quarantine pest or BCA may be 'present but not widely distributed'. This means that the pest has not reached the limits of its potential area of distribution either in the field or in protected conditions; it is not limited to its present distribution by climatic conditions or host-plant distribution. There should be evidence that, without phytosanitary measures, the pest would be capable of additional spread. If the pest is present but not widely distributed in the PRA area, it may already be under official control, with the aim of eradication or containment. If it is not already under official

control and if the conclusion of this PRA is that it should be regulated as a quarantine pest, then the pest should also be placed under official control.

No

Potential for establishment and spread in the PRA area

For a pest/BCA to establish, it should find hosts or suitable habitat in the PRA area. Natural hosts should be of primary concern but, if such information is lacking, species which are recorded as hosts only under experimental conditions or accidental/very occasional hosts may also be considered. The pest should also find environmental conditions suitable for its survival, multiplication and spread, either in natural or in protected conditions.

2.07 Does at least one host species occur in the PRA area (outdoors, in protected cultivation or both)?

Note: if the PRA is conducted on a BCA which indirectly affects species through effects on other organisms, these organisms should also be present in the PRA area. Some pests require more than one host species to complete their life cycle and this should be taken into account when answering this question.

Yes, the preferred host is *D. kuriphilus* and this species is established outdoors in South-East England. *Torymus sinensis* can complete its lifecycle on this host.

2.08 If a vector is the only means by which the pest can spread, is a vector present in the PRA area?

Note: if a vector is the only natural means by which the BCA can spread and when it is absent from the PRA area, a separate PRA to determine the risk of introduction of the vector may be needed.

No vector is required.

2.09 Does the known area of current distribution of the pest include ecoclimatic conditions comparable with those of the PRA area or sufficiently similar for the pest to survive and thrive (consider also protected conditions)?

The bioclimatic similarity between the UK and the locations of established populations of *T. sinensis* was assessed using General Niche-Environment System Factor Analysis (GNESFA; Callenge & Basille 2008). See Appendix 1.

The climatic modelling indicates that there are locations in the UK where the climatic conditions are similar to other areas where populations of *T. sinensis* are established across the world. This would suggest that it should be possible to establish self-sustaining biocontrol populations of *T. sinensis* in the UK.

The areas identified as climatically similar include Farningham Woods (where the presence of OCGW was identified in 2015) and the locations in London at which OCGW has been found in 2016.

Given the coarse nature of the analysis, the presented climatically suitable areas only represent an approximation of the range where releases of *T. sinensis* may be successful, and it is very possible that the true climatic range constraints encompass a larger area than currently mapped, including St Albans.

<u>Potential for economic consequences in PRA area</u>

> There should be clear indications that the pest is likely to have an unacceptable economic impact in the PRA area. Unacceptable economic impact is described in ISPM No. 5 Glossary of phytosanitary terms, Supplement No. 2: Guidelines on the understanding of potential economic importance and related terms. Climatic and cultural conditions in the PRA area should be considered to decide whether important economic (including environmental or social) damage or loss may occur in the PRA area. The effect of the presence of the pest on exports from the PRA area should also be allowed for. In some cases, the pest may only be potentially harmful, as suggested by its intrinsic attributes.

2.10 With specific reference to potential hosts and habitats in the PRA area, and the damage or loss caused by the pest in its area of current distribution, could the pest by itself, or acting as a vector, cause significant damage or loss or other negative economic impacts (on the environment, on society, on export markets) through its effect in the PRA area?

> *Note*: "through the effect on plant health" means that the organism should have a direct or indirect effect on plants. ISPM n° 11 states that "*Environmental effects and consequences considered should result from effects on plants. Such effects, however, on plants may be less significant than the effects and/or consequences on other organisms or systems. For example, a minor weed may be significantly allergenic for humans or a minor plant pathogen may produce toxins that seriously affect livestock. However, the regulation of plants solely on the basis of their effects on other organisms or systems (e.g. on human or animal health) is outside the scope of this standard. If the PRA process reveals evidence of a potential hazard to other organisms or systems, this should be communicated to the appropriate authorities which have the legal responsibility to deal with the issue.*"

Torymus sinensis is not a plant pest and is not known to be a vector of any plant pathogens. It feeds on *D. kuriphilus* which is a plant pest. In all areas of Europe where *T. sinensis* has been deliberately released for the biological control *D. kuriphilus*, it has been reported to have reduced the populations of *D. kuriphilus* and thereby had a positive economic and environmental impact (Matošević *et al*., 2017). The long-term effects are less clear as *T. sinensis* has only recently been released into many new areas. Matošević *et al*. (2017) also reported that *T. sinensis* has successfully spread naturally from Italy across Slovenia to Croatia and Hungary. *Torymus sinensis* has also been found in Bosnia and Herzegovina where there have been no official releases. It also spread naturally from France into Spain (Nieves-Aldrey *et al*., 2019).

<u>Conclusion of pest categorization</u>

2.11 This BCA could present a risk to the RA area (Summarize the main elements leading to this conclusion)

In conclusion *T. sinensis* is a non-native parasitoid that if introduced to the RA area has the potential to present some risk to the environment. The main elements of this risk are:

- The direct and indirect non-target effects including effects on the ecosystem are not fully understood and may differ between Italy, where most research has been conducted, and the UK.
- Recent host expansion of *T. sinensis*. It has been found to parasitize 11 species of oak-galling wasp assigned to four genera that naturally occur in the RA area. The host-range appears to be expanding and is not fully understood.
- The population levels of *D. kuriphilus* are much lower in the UK and there may be increased pressure on *T. sinensis* to attack native oak galling wasps.
- The risk of hybridization with native *Torymus* species.

Go to section B

2.12 The BCA does not represent a risk for the RA area and the assessment for this pest can stop (summarize the main reason for stopping the analysis).

Section B: Assessment of the probability of establishment and spread and of potential consequences

Note: During pest categorization (Section A), the assessor may have identified factors which have a major influence on the overall evaluation (e.g. the climatic conditions for establishment appear to be critical). In such situations it is recommended that the assessor first considers the questions in section B that are relevant to these factors. Based on the evaluation of such questions, and if the conclusion is that the risk is very low or low, it may not be necessary to answer other parts of the scheme.

This part of the risk assessment process is based on the replies to a series of questions, mostly expressed in the first instance as the choice of an appropriate phrase out of a set of five alternatives (e.g. very unlikely, unlikely, moderately likely, likely, very likely). It is important to identify especially high or especially low risks. The user of the scheme should add to all replies any details which appear relevant indicating the source of information used. In addition, the level of uncertainty attached to each answer should be given.

Answer as many of the following questions as possible. If any question does not appear to be relevant for the pest concerned, it should be noted as "irrelevant". If any question appears difficult to answer no judgement should be given but the user should note whether this is because of lack of information or uncertainty.

Probability of Establishment

Selecting the ecological factors that influence the potential for establishment

Seven factors may influence the limits to the area of potential establishment and the suitability for establishment within this area:

1. Host species and suitable habitats
2. Alternate hosts and other essential species
3. Climatic suitability
4. Other abiotic factors
5. Competition and natural enemies
6. The managed environment
7. Protected cultivation

Host species (and suitable habitats) and climate are always influencing the potential of establishment, and will therefore always be taken into account. For the other factors listed here, there is often little or no information available for use by risk assessors and so they cannot be evaluated. In order to identify which factors need to be considered use the table to select which of the questions you will answer in detail.

The following table is designed to select only those factors that need to be assessed:

(i) to delimit the area where there is a potential for establishment

- answer YES or NO to the questions in column A

(ii) to determine the suitability of this area for establishment

- answer YES or NO to the questions in column B

No.	Factor	Column A **Is the factor likely to have an influence on the limits to the area of potential establishment?**	Column B **Is the factor likely to have an influence on the suitability of the area of potential establishment?**
1	Host species and suitable habitats (*see note for Q3.01*)	Answer Q3.01.	Answer Q3.09.
2	Alternate hosts and other essential species (*see note for Q3.02*)	Only if relevant, answer YES OR NO. If YES answer Q3.02. If NO provide a justification.	Only if relevant, answer YES OR NO. If YES answer Q3.10. If NO provide a justification.
3	Climatic suitability (*see note for Q3.03*)	Answer Q3.03.	Answer Q3.11.
4	Other abiotic factors (*see note for Q3.04*)	Answer YES OR NO. If YES provide a justification. If NO provide a justification answer Q3.04.	Answer YES OR NO. If YES answer Q3.12. If NO provide a justification.
5	Competition and natural enemies (*see note for Q3.05*)	Answer YES OR NO. If YES answer Q3.05. If NO provide a justification.	Answer YES OR NO. If YES answer Q3.13. If NO provide a justification.
6	The managed environment (*see note for Q3.06*)	Answer YES OR NO. If YES answer Q3.06. If NO provide a justification.	Answer Q3.14 and 3.15.
7	Protected Cultivation (*see note for Q3.07*)	Answer YES OR NO. If YES answer Q3.07. If NO provide a justification.	Answer YES OR NO. If YES answer Q 3.16. If NO provide a justification.

Summarise the table to list the questions in column A (where you have responded YES) that will now need to be answered to delimit the area of potential establishment and go to question 3.01. Answer only these questions and question 3.08 to identify the area.

Summarise the table to list the questions in column B (where you have responded YES) that will now need to be answered to assess the suitability of the area of potential establishment. Once you have completed Question 3.08, go to question 3.09 and only answer these questions.

In the first sub-section entitled ***Identification of the area of potential establishment***, the questions act cumulatively to delimit the area.

In the second sub-section called ***Suitability of the area of potential establishment***, the suitability of this area is assessed.

Identification of the area of potential establishment

Factor 1 host species and suitable habitats

3.01 Identify and describe the area where the host species or suitable habitats are present in the RA area outside protected cultivation.

Note: For EU cultivated plant hosts consult country production data from FAOSTAT and EUROSTAT. For more detailed crop distribution data use JRC, SEAMLESS and McGill University crop distribution maps and country datasets. For uncultivated plant distributions explore global (e.g. GBIF), European (e.g. Florae Europaeae), regional and country flora. For habitat distributions consult maps prepared by the European Environment Agency, CORINE, EUNIS, etc. The distribution can be described by national region, country, by continental region (e.g. south-western Europe) or by environmental zone (e.g. the Mediterranean).

It is considered highly probable that *T. sinensis* will establish in southern England, wherever the host *D. kuriphilus* and *C. sativa* are found. This area of greatest potential establishment is the South-East of England including the following English counties: Bedfordshire, Berkshire, Buckinghamshire, East Sussex, Hertfordshire, Greater London, Hampshire, Isle of White, Kent, Oxfordshire, Surrey and West Sussex.

Factor 2 alternate hosts and other essential species

3.02 Does all the area identified in 3.01 have alternate hosts or other essential species if these are required to complete the pest's life cycle?

Note: The pest needs more than one host or another essential species to complete its life cycle or for a critical stage of its life cycle such as transmission (e.g. vectors), growth (e.g. root symbionts), reproduction (e.g. pollinators) or spread (e.g. seed dispersers).

If Not Required: Record this information.

If Yes: Record this information and provide justification.

If No: Based on the area assessed as being suitable for establishment in question 3.01, identify and describe the area where alternate hosts or other essential species are present. Describe how this affects the area where hosts and suitable habitats are present.

Go to the next question.

Torymus sinensis does not need alternative hosts or other essential species. However, it has been reared from 11 other oak-gall forming species that occur in the RA area, although the incidence is very low (only 0.01% of adult chalcids reared from 14,512 non-target galls were *T. sinensis*), and it is therefore unlikely that these could support a viable population of *T. sinensis*.

<u>Factor 3 climatic suitability</u>

3.03 Does all the area identified as being suitable for establishment in previous questions have a suitable climate for establishment?

> *Note:* When comparing climates in a pest's current distribution with those in the PRA area, it is important to ensure that, as far as possible, the variables selected are relevant to the pest's ability to exploit conditions when these are favourable for growth and reproduction and to survive unfavourable periods, such as those of extreme cold, heat, wetness or drought. It may be helpful to compare the global distribution of the pest and its hosts. If they have similar climatic responses, all the hosts in the PRA area might be considered to be at risk and a Yes response may be appropriate. In situations where this question is difficult to answer it may be useful to consult the maps provided in the appendices to the guidance for question 3.11.

If Yes: Record this information and provide justification,

If No: Based on the area assessed as being suitable for establishment in previous questions, identify and describe the area where the climate is like that in the pest's current area of distribution. Describe how this affects the area identified where hosts, suitable habitats and other essential species are present.

The bioclimatic similarity between the UK and the locations of established populations of *T. sinensis* was assessed using General Niche-Environment System Factor Analysis (GNESFA; Callenge & Basille 2008). See Appendix 1.

The climatic modelling indicates that there are locations in the UK where the climatic conditions are similar to other areas where populations of *T. sinensis* are established across the world. This would suggest that it should be possible to establish self-sustaining biocontrol populations of *T. sinensis* in the UK.

The areas identified as climatically similar include Farningham Woods (where the presence of OCGW was identified in 2015) and the locations in London at which OCGW has been found in 2016.

Given the coarse nature of the analysis, the presented climatically suitable areas only represent an approximation of the range where releases of *T. sinensis* may be successful, and it is very possible that the true climatic range constraints encompass a larger area than currently mapped, including St Albans in Hertfordshire, where *D. kuriphilus* was detected in 2015.

Figure 3. Locations in the UK and Europe where the bioclimatic conditions are similar to those locations where *Torymus sinensis* has been recorded

Go to the next question.

Factor 4 other abiotic factors

3.04 Does all the area identified as being suitable for establishment in previous questions have other suitable abiotic factors for establishment?

Note: the major abiotic factors to be considered are the physical and chemical characteristics of the soil; others include, for example, environmental pollution and topography/orography. For organisms having an aquatic stage, pH, salinity, current and temperature are important factors to consider.

If Yes: Record this information and provide justification,

If No: Based on the area assessed as being suitable for establishment in previous questions, identify and describe the area that is not under protected cultivation where additional abiotic factors that can affect establishment are favourable. Describe how this affects the area identified where hosts, suitable habitats and other essential species are present.

Go to the next question.

There appears to be no detailed information available on the major abiotic factors required for the establishment of *T. sinensis* or for enabling the extended pupal diapause. The distribution will clearly be limited by the availability of suitable gall-wasp hosts, which are limited by the availability of suitable host plants and *Castanea* do not grow well on chalk. Therefore *T. sinensis* is likely to be less common in areas such as the chalk escarpments of the North and the South Downs.

Factor 5 competition and natural enemies

3.05 Is all the area identified as being suitable for establishment in previous questions likely to remain unchanged despite the presence of competitors and natural enemies?

If Yes: Record this information and provide justification,

If No: Identify and describe any locations where the area suitable for establishment based on previous questions is likely to be altered due to competition and natural enemies. Provide justification.

Go to the next question.

Dryocosmus kuriphilus is a recent non-native introduced species and there are no native parasitoids in the UK that rely on it for their existence. Six native species of parasitoids have been reared from (or found in association with) *D. kuriphilus* galls in the UK of which the dominant species by far is *T. flavipes.* There will therefore be some competition with native parasitoid species although all the native parasitoids are polyphagous and have alternative hosts. All the native parasitoid species can act as hyperparasitoids and may kill *T. sinensis* larvae. The impact of native hyperparasitoids on *T. sinensis* in the UK is unknown but it has not been significant in Europe where *T. sinensis* has been used as a biological control agent and where the same native hyperparasitoid species occur. However, hyperparasitism has had a significant effect on *T. sinensis* in the USA (Cooper & Rieske, 2011).

Factor 6: the managed environment

3.06 Is all the area identified as being suitable for establishment in previous questions likely to remain unchanged despite the management of the environment?

Note: factors that should be considered include cultivation practices such as the time of year that the crop is grown, soil preparation, method of planting, irrigation, surrounding crops, time of harvest, method of harvest, soil water balance, fire regimes, disturbance, etc. Factors to consider for pest plants are for instance the regular mowing of road sides, cleaning of water courses, etc. Existing pest management practice should also be considered.

If Yes: Record this information and provide justification,

If No: Identify and describe any locations where the area suitable for establishment based on previous questions is likely to be altered due to the management of the environment. Provide justification.

The areas identified as being suitable for establishment are likely to remain largely unchanged although sections of some of the woods will be coppiced. Most of the identified areas contain mature trees, e.g. parkland, protected areas, roadside trees.

Go to the next question.

Factor 7: protected cultivation

3.07 Are the hosts grown in protected cultivation in the PRA area?

> *Note: "*Protected cultivation" in the context of this scheme means synthetic or glass structures (e.g. glasshouses) which provide suitable conditions for host growth, protecting them from adverse environmental extremes.
>
> The pest may already have been recorded in protected cultivation elsewhere, but it may also happen that the host is grown outside in the area where the pest is present and the possibility that hosts under protected cultivation can be infected/infested has to be considered.

If No: Record this information and provide justification.

If Yes: Identify and describe the areas where the hosts are grown in protected cultivation or – if the pest is a plant - where similar protected cultivation occurs in the PRA area. Provide justification.

No host plants, sweet chestnut (and oak), are grown in protected cultivation.

Go to the next question.

Area of potential establishment

3.08 By combining the cumulative responses to those questions 3.01 to 3.06 that have been answered with the response to question 3.07, identify the part of the RA area where the presence of host plants or suitable habitats and other factors favour the establishment of the pest.

> Note: The area of potential establishment may be the whole of the PRA area, or part or parts of the area (i.e. the whole EPPO region or whole or part of several countries of the EPPO region). It can be defined eco-climatically, geographically, by crop or by production system (e.g. protected cultivation such as glasshouses) or by types of ecosystems.

The climatic modelling indicates that there are limited locations in the UK where *T. sinensis* has the potential to establish self-sustaining biocontrol populations. This includes areas in the South-East of England where sweet chestnuts are common and the host *D. kuriphilus* is likely to be already established or will establish in the future. In conclusion, *T. sinensis* is likely to establish in East Sussex, Kent, Surrey and West Sussex.

It should be noted, however, that the climatic modelling only represents an approximation of the range where releases of *T. sinensis* may be successful, and this is the reason why the RA assessment area has been set as anywhere in the UK where sweet chestnut is grown. In addition, *T. sinensis* is still spreading in its introduced range and therefore it isn't entirely climatic factors which lead to the restricted distribution in Europe & North America. This doesn't affect the conclusion that parts of the UK will be suitable for *T. sinensis*, but it is highly likely to underestimate the potential area of the UK which is suitable.

Suitability of the area of potential establishment

Questions 3.09-3.16 should be answered following the summarising table above. Questions 3.17-3.20 should always be answered.

<u>Availability of suitable hosts or suitable habitats, alternate hosts and vectors in the PRA area</u>

3.09 How likely is the distribution of hosts or suitable habitats in the area of potential establishment to favour establishment?

> *Note:* In question 3.01 the area where host species or suitable habitats are present in the PRA area was identified but here we are assessing the abundance and patchiness of the distribution of host species or suitable habitats in the area of potential establishment defined in question 3.08. See also the note for question 3.01.

The density of sweet chestnut trees and average density of *D. kuriphilus* galls is much lower in most areas of the UK than found in Italy and it is unclear how this will affect establishment of *T. sinensis*. However, in 2019 high densities of *D. kuriphilus* galls were observed at Farningham Woods in Kent (up to 142 galls/m of terminal branch), following the exceptionally hot summer of 2016. The average gall density observed in South East England may increase in the future.

very unlikely, unlikely, **<u>moderately likely</u>**, likely, very likely

Level of uncertainty:	Low	Medium	High X

3.10 How likely is the distribution of alternate hosts or other species critical to the pest's life cycle in the area of potential establishment to favour establishment?

> *Note:* Although this is based on the answer to question 3.02, in this question the abundance and patchiness of the distribution of alternate hosts and other species critical for the life cycle in the area of potential establishment (defined in question 3.08) is evaluated. For examples, see note for question 3.02.

No significant alternative hosts have been reported elsewhere in Europe. However, because the population levels of *D. kuriphilus* are low in England, it is possible that the 11 potential non-target hosts (and others that have not yet been identified) could be more significant.

There are no UK gall wasp species that are of conservation concern.

very unlikely**, <u>unlikely</u>**, moderately likely, likely, very likely

Level of uncertainty:	Low	Medium X	High

<u>Suitability of the environment</u>

3.11 Based on the area of potential establishment already identified, how similar are the climatic conditions that would affect CBA establishment to those in the current area of distribution?

> *Note:* In question 3.03 the area where climate is suitable for establishment in the PRA area was determined but here the extent to which the climate is suitable in the area for potential establishment (defined in question 3.08) is assessed. Using pest distribution maps and maps of world climate zones (e.g. the Köppen-Geiger zones), identify the climates where the pest is currently present. Then, compare these with the climates in the area for potential establishment (defined in question 3.08). The relative distributions of the hosts and the pest in areas where the pest is not still spreading may help indicate whether both the hosts and the pest have similar climatic responses. It is important to take into account the fact that the relationship between the current pest distribution and climate may not be clear because (a) the current pest distribution is poorly known, (b) the species is still spreading, (c) the limits to its distribution depend on factors such as the presence of hosts or geographical barriers e.g the sea or mountains, rather than climate and (d) climate, as measured at weather stations, is unrelated to the microclimate inhabited by the species because it completes much of its life cycle in protected or irrigated cultivation, submerged aquatic habitats, the soil, thick woody plant tissue or in vectors.

Climatic modelling indicates it should be possible for *T. sinensis* to establish self-sustaining biocontrol populations in South-East England (for example East Sussex, Kent, Surrey and West Sussex) where sweet chestnuts and *D. kuriphilus* occur.

not similar, slightly similar, moderately similar, **largely similar**, completely similar

Level of uncertainty:	Low X	Medium	High

3.12 Based on the area of potential establishment, how similar are other abiotic factors that would affect pest establishment to those in the current area of distribution?

> *Note:* This question evaluates the extent to which the abiotic factors are suitable in the area of potential establishment.
>
> The major abiotic factors to be considered are the physical and chemical characteristics of the soil; others are, for example, environmental pollution, topography/orography. For organisms having an aquatic stage, pH, salinity, current and temperature are important factors to consider.

Dryocosmus kuriphilus galls in the UK form approximately a month later than those observed in Italy and the majority form on the leaf lamina. The consequence of this is that most galls fall to the ground in autumn, unlike the galls in Italy which form at the very base of the leaves or on the apical twigs and remain attached to the trees in winter. It is also unclear how this difference will affect overwintering mortality rates of *T. sinensis*.

not similar, slightly similar, **moderately similar**, largely similar, completely similar

Level of uncertainty:	Low	Medium	High X

3.13 Based on the area of potential establishment, how likely is it that establishment will occur despite competition from existing species, and/or despite natural enemies already present?

Note: See question 3.05

Competition and hyper-parasitism have had a very low impact on establishment in continental Europe. Hyper-parasitism, however, has had a significant effect on *T. sinensis* in the USA (Cooper & Rieske, 2011). Competition and hyper-parasitism and are not expected to have a major impact on establishment of *T. sinensis* in the UK although there is some uncertainty regarding this.

very unlikely, unlikely, moderately likely, likely, **very likely**

Level of uncertainty:	**Low**	**Medium X**	**High**

Cultural practices and control measures

3.14 How favourable for establishment is the managed environment in the area of potential establishment?

Note: see question 3.06. This question refers to the situation outdoors, i.e. not in protected crops.

The managed environment e.g. parkland, coppiced woodland, are likely to be highly favourable for the establishment of *T. sinensis*.

Not at all favourable, slightly favourable, moderately favourable, **highly favourable**, very highly favourable

Level of uncertainty:	**Low X**	**Medium**	**High**

3.15 How likely is the pest to establish despite existing pest management practice?

There are no management measures taken against parasitoid wasps as they are beneficial. Coppicing in some sweet chestnut orchards may remove some *D. kuriphilus* galls (and possibly *T. sinensis* if released) but the new sweet chestnut growth in subsequent years appears to have higher densities of galls which will provide more food for *T. sinensis*. Only part of a sweet chestnut wood is coppiced at any one time.

Pest management practices are very unlikely to influence whether *T. sinensis* can establish.

very unlikely, unlikely, moderately likely, likely, very likely.

Level of uncertainty:	**Low X**	**Medium**	**High**

3.16 Is the BCA likely to establish in protected cultivation in the RA area?

> *Note:* For crops in Northern/Central Europe and pests from warmer climates: is the relevant crop grown under protected conditions? This sub-question is only relevant for pests that cannot establish outdoors in the PRA area.

Dryocosmus kuriphilus does not occur under protected cultivation in the RA area.

Yes

No

Level of uncertainty:	Low X	Medium	High

Other characteristics of the pest affecting the probability of establishment

3.17 How likely are the reproductive strategy of the pest and the duration of its life cycle to aid establishment?

> *Note:* consider characteristics which would enable the pest to reproduce effectively in a new environment and answer the following sub questions either yes or no (some may not be appropriate for the pest taxon studied, these should be identified and do not need to be answered)

Torymus sinensis is reported to be univoltine. However, in North-West Italy it exhibits a prolonged diapause, mainly as late instar larvae, which extends for 12 months, and adults emerge in April as usual, showing a two-year life cycle. The extended diapause plays an important role for the establishment of *T. sinensis* especially in the first years after its release. If there is poor synchronisation between the emergence of the adult *T. sinensis* and development of the *D. kuriphilus* galls in one year, some of the adults won't emerge until the next spring when synchronisation may be improved. In England, however, *T. sinensis* with extended diapause in galls on the ground may increase mortality rates and reduce the chances of establishment.

There is moderate uncertainty regarding the synchronisation in the UK climate and how the BCA will establish when the host is at low density.

very unlikely, unlikely, **moderately likely,** likely, very likely

Level of uncertainty:	Low	Medium X	High

3.18 Is the BCA highly adaptable?

> *Note:* Evidence of variability may indicate that the pest has a greater capacity to withstand environmental fluctuations, to adapt to a wider range of habitats or hosts, to develop resistance to plant protection products and to overcome host resistance. If the answer to this question is yes, this is an important indication that this species is likely to have a greater potential for

establishment. In addition, the magnitude of future impacts may increase. High adaptability also indicates that data from the native range, e.g. on climatic responses and host range, may not continue to be representative of the population in the PRA area so that the PRA itself may need revision at a shorter interval. Furthermore, if adaptability is high, this needs to be kept in mind with regard to effective management measures. Examples of high adaptability include *Bemisia tabaci* which clearly seems to be able to evolve quickly to produce new biotypes, to develop insecticide resistance and to expand its host range and *Phytophthora ramorum*, which also appears to be rapidly increasing its host range.

If the pest is highly or very highly adaptable, this should be mentioned in the section degree of uncertainty.

Torymus sinensis appears to be 'highly adaptable' as it has established in several new geographical areas with temperate and subtropical climates and has recently exhibited host expansion. There is a moderate degree of uncertainty as there are still areas of its biology that need further research.

YES, highly or very highly adaptable

NO, moderately adaptable or less

Not relevant

Level of uncertainty:	Low	Medium X	High

3.19 How widely has the BCA established in new areas outside its original area of distribution? (specify the instances, if possible; note that if the original area is not known, answer the question only based on the countries/continents where it is known to occur)

Torymus sinensis is native to China and has been introduced and become established in Croatia, France, Hungary, Italy, Japan, Portugal, Slovenia, Spain, Turkey and the USA.

Not established in new areas, not widely, moderately widely, widely, **very widely**

Level of uncertainty:	Low X	Medium	High

Conclusion on the probability of establishment

3.20 The overall probability of establishment should be described.

Climatic suitability and host availability indicate that *T. sinensis* will be able to establish in part of the RA area (South-East England). Post-release surveys at 50 sites in France demonstrated a very high local establishment of *T. sinensis*, regardless of the introduction method. Post-introduction dynamics followed a two-phase process. First, early dynamics were characterized by an exponential growth of *T. sinensis* populations without a significant decrease in *D. kuriphilus* populations. Later, middle-term dynamics indicated a global decrease in both *D. kuriphilus* and *T. sinensis* populations. Release site connectivity had a positive effect on *T. sinensis* population size, suggesting successful colonization and establishment at a wide spatial scale beyond the introduction sites (Borowiec *et al*., 2018). Factors that may interfere with establishment in England include the relative low density of sweet chestnuts, low density of *D. kuriphilus* galls, mortality of *T. sinensis* in galls overwintering on the ground, potential effects of hyperparasitism, and the effect of climate on synchronisation between the gall formation and *T. sinensis* adult emergence. However, regarding the later issue, Borowiec *et al*. (2018) found that *T. sinensis* developmental time varied considerably, which may be interpreted as a 'hedging your bets' strategy against environmental stochasticity. These findings indicate the adaptability and potential of *T. sinensis* for successful establishment and sustainable control of the chestnut gall wasp in England.

Very low, low, medium, **high**, very high

Level of uncertainty:	**Low**	**Medium X**	**High**

Probability of spread

Spread is defined as the expansion of the geographical distribution of an organism within an area. Spread potential is an important element in determining how quickly impact is expressed and how readily an organism can be contained. In the case of intentionally imported organisms, the assessment of spread concerns spread from the intended habitat or the intended use to an unintended habitat, where the pest may establish. Further spread may then occur to other unintended habitats. The nature and extent of the intended habitat and the nature and amount of the intended use in that habitat will also influence the probability of spread. Some organisms may not have injurious effects on species immediately after they establish, and in particular may only spread after a certain time. In assessing the probability of spread, this should be considered, based on evidence of such behaviour.

4.01 What is the most likely rate of spread by natural means (in the RA area)?

Note: Natural population spread, increasing the infested area, can result from the movement of the pest by flight (of an insect), wind or water dispersal (except irrigation), transport by vectors such as insects, birds or other animals (internally through the gut or externally on the fur), natural migration, rhizomial growth.

Consider potential vectors of the pest in the PRA area, the presence of natural barriers, and the suitability of the environment. In this question the mean rate of spread should be taken into account to decide on the rating. The maximum spread capacity should be described in the justification text and the corresponding rating may also be given when the assessors considers it important to describe different scenarios.

Spread can be described as distance covered per unit time (e.g. 50 m /year) or in increasing area occupied (e.g. km^2) over time.

Dryocosmus kuriphilus is widely established in Italy and its spread follows a stratified dispersal pattern. Analysis of local random diffusion suggests an average rate of short distance natural dispersal in Europe of 8 km/year (EFSA, 2010). There is no such detailed comparable data available for *T. sinensis* which is much harder to detect in the field.

Torymus sinensis may disperse over long distances through active flight or wind assistance to reach non-release sites (Colombari & Battisti 2016; Ferracini *et al*., 2019; Matošević *et al*., 2017; Moriya *et al*., 2003).

Everatt (2015) reported that *T. sinensis* has a very high spread potential. While the spread of the parasitoid during the first years of release in Japan and Italy was slow (< 1 km/year), seven years after the first release in Japan the parasitoid travelled at a rate of 60 km/year (Moriya *et al*., 2003), and was reported to spread over most of Tuscany in 2008-2009. These figures should be viewed with caution, however, as *T. sinensis* was readily available in Italy in 2008, and possibly also in Japan, and could have been released by private owners with no record taken. The spread may therefore not be due to natural dispersal.

Torymus sinensis has been found in Bosnia and Herzegovina where there have been no official releases. However, *T. sinensis* was deliberately released in to neighbouring Croatia in 2015 for the control of *D. kuriphilus*. *Torymus sinensis* has dispersed across the border into Bosnia and Herzegovina and it is unclear whether this was natural or anthropogenic.

It is unlikely that the rate of spread of *T. sinensis* in England will be the same as Italy and Japan because much lower population levels are expected (due to much lower *D. kuriphilus* gall numbers/density and potentially higher winter mortality as a greater proportion of galls overwinter on the ground), and cooler spring temperatures when the adults are active. It is therefore concluded here that *T. sinensis* could have a moderate to high rate of spread with medium uncertainty.

Very low rate of spread, low rate of spread, **moderate rate of spread**, high rate of spread, very high rate of spread

Level of uncertainty:	**Low**	**Medium X**	**High**

4.02 What is the most likely rate of spread by human assistance (in the RA area)?

Note: consider the potential for movement with commodities, packing materials, baggage, mail or conveyances, the fact that the species is intentionally dispersed by people and the ability of the pest to be unintentionally dispersed along major transport routes. Mechanical transmission through human activities (by grafting or budding and contamination of hands, clothing and tools used for pruning, cutting, thinning and preparing the soil) commonly occurs over short distances within the place of production. However, since employees often travel long distances to work and contract workers (that visit many production sites) are commonly employed, it is considered that evidence of mechanical transmission indicates the potential for at least moderate spread.

It is proposed that *T. sinensis* would be deliberately released at several sites in South-East England over a relatively large area (= high rate of spread). However, it is not envisaged that *T. sinensis* will be spread further accidently through human assistance although OCGW is a high-profile pest and somebody may deliberately spread it to 'help save the sweet chestnut trees'. It is also possible that *T. sinensis* adults will be accidently carried on vehicles (hitch-hiking) although the adults are active fliers and the risk appears low (= very low rate of spread).

Very low rate of spread, **moderate rate of spread**, high rate of spread, very high rate of spread

Level of uncertainty:	Low	Medium X	High

Conclusion on the probability of spread

4.03 Describe the overall rate of spread

Note: The overall rate for spread should combine the assessments of the rate for natural spread and human spread. In most situations the overall rate of spread equals the highest rate of spread given to either question 4.01 or 4.02.

It is therefore concluded here that *T. sinensis* could have a moderate rate of spread with medium uncertainty.

very low rate of spread, low rate of spread, **moderate rate of spread**, high rate of spread, very high rate of spread

Level of uncertainty:	Low	Medium X	High

The assessor should also give his/her best estimate for the following questions:

4.04 What is your best estimate of the time needed for the pest to reach its maximum extent in the RA area?

Note: In this question, ignore any containment measures that may be taken to prevent or contain the spread of the pest. The maximum extent can be considered to be the area of potential establishment defined in question 3.08.

The factors to be taken into account in deciding on the time to reach its maximum extent include:

- The rate of spread,
- The survival and reproductive rate
- The relationship between population density and impact thresholds

- The time taken for impacts to be observed, e.g. through a lag phase
- Climate and land use change

Torymus sinensis is likely to only be able to establish in part of the RA area, specifically the South East of England which is approximately 150 miles or 241 km in width. If *T. sinensis* was released and established in the centre and travelled at a moderate to high rate of spread, and assuming it required 2 years to establish (based on observations from Italy), it would take about 6 to 8 years to reach its maximum extent in the RA area. However, we are anticipating multiple releases at several sites which could shorten this period significantly, assuming *T. sinensis* establishes. The best estimate for the parasitoid wasp to establish and spread throughout the RA area is 5-8 years. There is high uncertainty as we do not know how *T. sinensis* will respond to the UK conditions, lower spring temperatures and low densities of galls compared with Italy.

Level of uncertainty:	**Low**	**Medium**	**High X**

4.05 Based on your responses to questions 4.01, 4.02, and 4.04 while taking into account any current presence of the pest, what proportion of the area of potential establishment do you expect to have been invaded by the organism after 5 years?

It is expected that *T. sinensis* could establish in approximately 30-50% of the RA area in a 4-8 years period.

Level of uncertainty:	**Low**	**Medium**	**High X**

Eradication or containment of the pest and transient populations

This section evaluates the likelihood that the pest could survive eradication programmes or be contained in case of an outbreak within the PRA area. It also considers if transient populations are likely to occur in the PRA area through natural migration or entry through man's activities.

5.01 Based on its biological characteristics, how likely is it that the pest could survive eradication programmes in the area of potential establishment?

Note: Some pests can be eradicated at any time (survival is very unlikely), others at an early stage (moderately likely) and others are very difficult to eradicate (very likely). Similarly, incursions of some pests may be difficult to find and/or delimit (very likely). Intentionally imported organisms may need to be eradicated from the intended habitat as well as from the unintended habitat.

Once established it would be very unlikely to contain or eradicate *T. sinensis*.

very unlikely, unlikely, moderately likely, likely, **very likely**

Level of uncertainty:	**Low X**	**Medium**	**High**

5.02 Based on its biological characteristics, how likely is it that the pest will not be contained in case of an outbreak within the RA area?

> *Note*: consider the biological characteristics of the pest that might allow it to be contained in part of the PRA area. For intentionally introduced organisms consider spread to the unintended habitat.

There are no practical measures available to contain an outbreak of *T. sinensis*.

very unlikely, unlikely, moderately likely, likely, **very likely**

Level of uncertainty:	Low X	Medium	High

5.03 Are transient populations likely to occur in the RA area through natural migration or entry through man's activities (including intentional release into the environment) or spread from established populations?

> *Note:* Transience is defined as the presence of a pest that is not expected to lead to establishment. The likelihood of transience should be assessed by considering the same factors taken into account when assessing establishment potential (e.g. climatic conditions). Damaging transient populations may occur outside the area of potential establishment, particularly in areas where climatic conditions are suitable during some period of the year (e.g. summer). In Southern Europe populations of *Bactrocera invadens* may enter through man's activities but are not expected to overwinter. Moth pests such as *Plusia gamma* and *Ostrinia nubilalis*, may enter through natural migration but summer populations are unable to survive low winter temperatures.

It is not known how *D. kuriphilus* was introduced into England and it is possible that *T. sinensis* will also be introduced in the future in the same manner, either naturally or by anthropogenic activities.

Yes

No

Level of uncertainty:	Low X	Medium	High

Post release monitoring

Dryocosmus kuriphilus galls and non-target galls (mainly from oak trees) will be collected in the late summer or early autumn before leaf fall from all the release sites (estimated 20 sites). The galls will be dissected open and the larvae/pupae will be identified using molecular methods. This is anticipated to continue for three to five years (or longer if considered necessary) to determine establishment, efficacy and non-target effects. There are no practical measures to control the spread of the wasp once it has established but it is likely to be limited by the distribution of *D. kuriphilus* galls.

Assessment of potential economic, environmental and social consequences

The main purpose of this section is to determine whether the introduction of the pest will have unacceptable economic consequences. It may be possible to do this very simply, if sufficient evidence is already available or the risk presented by the pest is widely agreed. Start by answering Questions 6.01–6.11. If the responses to question 6.04 and 6.05 are "major" or "massive" or any of the responses to questions 6.06, 6.09, and 6.11 is “major" or "massive” the evaluation of the other questions in this section may not be necessary and you can go to 6.15 unless a detailed study is required, or the answers given to these questions have a high level of uncertainty. In cases where the organism has already entered and is established in part of the RA area, responses to questions 6.01, 6.08 and 6.10, which refer to impacts in its area of current distribution, should be based on an assessment of current impacts in the RA area in addition to impacts elsewhere.

Expert judgement is used to provide an evaluation of the likely scale of impact. If precise economic evaluations are available for certain pest/host plant combinations, it will be useful to provide details.

The replies should take account of both short-term and long-term effects of all aspects of agricultural, environmental and social impact. When a qualitative impact assessment is conducted, there is no need to take the time constraint into account. An option is to evaluate the impact for different scenarios where different proportions of the area of potential establishment are considered to be invaded (e.g. 10 %, 25%).

In any case, providing replies for all hosts (or all habitats) and all situations may be laborious, and it is desirable to focus the assessment as much as possible. The study of a single case may be sufficient, e.g. if the effect on one host exceeds the effect on all other hosts together. It may be appropriate to consider all hosts/habitats together in answering the questions once, if effects on these hosts are comparable. If a selection is made, it should be justified. Only in certain circumstances will it be necessary to answer the questions separately for specific hosts or habitats. This is the case if the majority of the affected producers suffer minor or moderate impacts, but a small group suffers major or massive impacts.

When the RA is performed on a pest proposed for deregulation, the current impact noted in the area may be linked to the implementation of phytosanitary measures. The assessor should evaluate the possible impact for a scenario where these measures targeting the pest are withdrawn.

ECONOMIC IMPACT “SENSUS-STRICTO”

6.01 How great a negative effect does the BCA have on crop yield and/or quality of cultivated plants or on control costs within its current area of distribution?

Note: Effect on crop yield and/or quality are usually expressed as a relative decrease (%) per crop per ha or relative increase in total control costs. When following the rating guidance, it is important to take into account the annual variation in crop yield and quality that normally occurs in different crops. For some crops, e.g. those grown in protected conditions, such as tomatoes, cut flowers and pot plants, the annual yield fluctuations are normally very small and a yield loss greater than 10% can be considered as a massive impact. For crops with high yearly fluctuations, e.g. fruit and arable products and a loss of more than 50% would be needed before it can be considered to be a massive impact. Other crops, such as nursery stock, outdoor vegetables and forestry, take an intermediate position. The main causes of the fluctuation are due to the weather and the lower amount of protection provided, the higher the annual variation in yield. Other aspects to be taken into account include biennial bearing (e.g. fruit) which increases yield variation, whether the product is a bulk product (maize) or a high-quality product (e.g. roses) and whether the product is harvested annually (e.g. vegetables). The more quality is an important product feature, the lower the yield variation is. If product the production cycle takes more than one year (e.g. forestry), yield variation due to weather conditions are levelled.

Torymus sinensis does not have a negative effect on crop yield or quality. In contrast it has a positive effect on yield by reducing the population level of *D. kuriphilus* which increases nut yield (Down & Audsley, 2016). It can also have a positive effect by reducing the numbers of galls which at high densities can disfigure the tree and lower its amenity value when grown in public parks.

minimal, minor, moderate, major, massive

Level of uncertainty:	Low X	Medium	High

6.02 How great a negative effect is the BCA likely to have on crop yield and/or quality of cultivated plants in the RA area without any control measures?

Note: This information can be derived from trials where no measures are taken on some plots. Consider the note and the answer to question 6.01. The ecological conditions in the PRA area may be adequate for pest survival but may not be suitable for pest populations to build up to levels at which significant damage is caused to the host plant(s). Rates of pest growth, reproduction, longevity and mortality may all need to be taken into account to determine whether these levels are exceeded despite the presence of natural enemies. Consider also the effects on non-commercial crops, e.g. private gardens, amenity plantings.

Torymus sinensis is unlikely to have any direct effect on crop yield or quality. It is likely to have an indirect positive effect on quality by reducing the numbers of galls which at high densities can disfigure the tree and lower its amenity value.

minimal, minor, moderate, major, massive

Level of uncertainty:	Low X	Medium	High

6.03 How great a negative effect is the BCA likely to have on yield and/or quality of cultivated plants in the RA area without any additional control measures?

Note: Consider the note and answer to question 6.01 and consider the pest survival and population growth when producers only apply current crop protection measures.

Torymus sinensis is unlikely to have any direct effect on crop yield or quality.

minimal, minor, moderate, major, massive

Level of uncertainty:	Low X	Medium	High

6.04 How great a negative effect is the BCA likely to have on yield and/or quality of cultivated plants in the RA area when all potential measures legally available to the producer are applied, without phytosanitary measures?

Note: Consider the note and answer to question 6.01. Take into account the existing and potential control measures and their efficacy against the pest. Difficulty of control can result from such factors as lack of effective plant protection products against this pest, resistance to plant protection products, difficulty to change cultural practices, occurrence of the pest in natural habitats, private gardens or amenity land, simultaneous presence of more than one stage in the life cycle, absence of resistant cultivars.

Include both normal farm practice costs and costs of control of measures which are additional to the common agricultural practice and which are assumed to be taken from a sound managerial perspective, in particular:

- ease of detection of the pest: species that are difficult to detect will require a greater surveillance and monitoring effort which will indirectly result in higher production costs.
- treatment: treatment options may vary (plant protection products, physical removal, etc.) Treatment costs may be divided into operating (e.g. chemical, fuel, equipment) and labour (i. e. hours per ha).

Torymus sinensis is unlikely to have any direct effect on crop yield or quality.

minimal, minor, moderate, major, massive

Level of uncertainty:	Low X	Medium	High

6.05 How great an increase in production costs (including control costs) is likely to be caused by the pest in the PRA area in the absence of phytosanitary measures?

Note: This is evaluated on the basis of the relative increase (%) in total costs (e.g. €). Include the costs of all additional measures which are considered in question 6.04 and costs incurred to prevent environmental impacts. Consider also the answer to question 6.02.

There will be an initial cost involved with releasing *Torymus sinensis* but this is unlikely to affect production costs of sweet chestnut timber.

minimal, minor, moderate, major, massive

Level of uncertainty:	Low X	Medium	High

6.06 Based on the total market, i.e. the size of the domestic market plus any export market, for the plants and plant product(s) at risk, what will be the likely impact of a loss in export markets, e.g. as a result of trading partners imposing export bans from the RA area?

Note: consider whether plant products potentially affected by the pest are exported from the PRA area and how important such exports are, for example by estimating the proportion of production that is exported. Take into account the major existing (or potential) export markets and how likely each is to impose an export ban from the PRA area. This is expressed as a relative decrease in market size.

There will be no loss in export markets for sweet chestnut timber.

minimal, minor, moderate, major, massive

Level of uncertainty:	Low X	Medium	High

6.07 To what extent will direct impacts be borne by producers?

Note: This is evaluated as the proportion (%) of total economic impact (the sum of the questions 6.04, 6.05 and 6.06) borne by the producers. Producers can try to transfer economic losses to consumers and to other producers in order to decrease impacts on themselves.

Factors that enable producers to decrease impacts include:

- the alternative use of the product, e.g. a shift from human consumption to use for animal feed
- the negotiation power of the producer to change the price of the product,
- the potential to grow other crops.

The ease with which production can be adjusted depends on:

- the time needed for new crops to reach full production, e.g. one season for potatoes and several years for apples,
- the availability of factors such as labour, land and the investments which may have to be made to increase production (investment in plants for planting, buildings such as glasshouses, etc.),
- factors such as market expectations and the potential for storage of the product until prices rise.

Factors that limit producers capacity to decrease impacts include:

- consumer responsiveness (can consumers postpone consumption or shift to substitutes?),
- reductions in market share due to loss of image or dependency on the harmed products, such as wood which is used as packaging material. This can also affect the sale of products which are not infested.

A producer will almost never be able to pass on all costs.

When no judgment is chosen, the assessor should specify in the PRA that the impact may be overestimated.

No direct impacts will be borne by producers.

minimal, minor, moderate, major, massive

Level of uncertainty:	Low X	Medium	High

ENVIRONMENTAL IMPACT

Questions to be answered to assess environmental impact are different for pests and for plants. Choose the relevant set of questions below (A or B respectively).

- *A. Questions for pests which are not plants*

6.08. How important is the environmental impact caused by the BCA within its current area of invasion? *(Answer the sub-questions below)*

Torymus sinensis has been deliberately introduced to many countries to control *D. kuriphilus*.

N/A, Minimal, minor, moderate, major, massive

6.08.0A Based on the elements explained in the note, do you consider that the question on the environmental impact caused by the pest within its current area of invasion can be answered?

Note: in this question we rate the current environmental impact in other invaded regions that can be used as indicator for determining the potential environmental impact in the RA area (Q. 6.09).

If the species has not invaded any other area, or if the invasion is too recent and too little is known about its ecology in the invaded areas, this question cannot be answered properly (assuming that no additional investigations can be undertaken during the time available for producing the PRA). The assessor may choose to go directly to Q 6.09. He/she may also choose to answer these questions based on well-studied closely-related species or data for the target species from the region of origin. Although the concept of "environmental impact" of an indigenous species on native biodiversity and ecosystem is debatable, in some cases native species clearly have an environmental impact, usually resulting either from climate change or ecological mismanagement (e.g. *Dendroctonus ponderosae* presently causing serious outbreaks and extending its range in Canada, various weeds now invasive in their native range, etc.). Nevertheless, the assessor should take into account the fact that the environmental impact of a pest in its region of origin is often a very poor predictor of potential impact in regions where it has been introduced. In particular, the absence of any obvious environmental impact in a region of origin should not be considered as a predictor for a low impact in a new area.

When data on impact are available in several invaded regions, priority should be given to impact observed in regions that are most closely related, geographically and eco-climatologically, to the PRA region. However, data from other regions should not be excluded. For example, when performing a PRA on an invasive pest for the entire Europe, data on impact already observed in Europe should be given priority, but information from other regions should also be provided. In any case, the assessor should specify the region where the information on impact has been gathered.

There have been no significant negative environmental impacts recorded in any countries where *T. sinensis* has been deliberately introduced. There have been some non-target effects in Italy and hybridization in Japan, but the environmental consequences appear to have been negligible.

Q 6.09. How important is the environmental impact likely to be in the PRA area?

Based on the observations from countries where *T. sinensis* has been introduced, it is expected that *T. sinensis* will have a minimal negative environmental impact. It is expected to have a positive impact by reducing the populations of *D. kuriphilus* which may help mitigate the impact of chestnut blight, a regulated disease recently found in England.

There are relatively few cynipid galls found on non-*Quercus* hosts in the UK and *T. sinensis* is unlikely to have a negative impact on the wider environment.

Minimal, minor, moderate, major, massive

Verify that, based on Q 6.08, an environmental impact is also likely to occur in the PRA area, and, if yes, at a comparable level, using the following questions. For this, answers to the section in the "likelihood of establishment" section should be taken into account:

To answer this question, begin at 6.09.0A

6.09.0A Does the same native species or community, or the same threatened ecosystem services, occur in the RA area and, if not, is it known whether the native species or communities, or ecosystem service in the RA area are similarly susceptible?

There has been a lot of research on non-target effects conducted in Italy (Ferracini *et al*., 2015 and 2017 – see section 1.05). A post-release study was performed to assess the impact of *T. sinensis* on native cynipid gall inducers in Italy. In total, 14,512 non-target galls were collected (mainly from oak but also from wild rose), corresponding to seven genera: *Andricus, Aphelonyx, Biorhiza, Cynips, Diplolepis, Neuroterus*, and *Synophrus*, and 8708 adult chalcid parasitoids were reared. The Torymidae family accounted for about 30%, and *Bootanomyia* (= *Megastigmus*) *dorsalis*, *Torymus affinis* and *T. flavipes* were the most represented species. A total of 116 *T. sinensis* emerged from 15 different species of oak gall forming wasp (see section 1.05 for further details), mainly *Andricus curvator* and *A. inflator*. In controlled conditions, oviposition was recorded on *A. cydoniae, A. grossulariae* and *A. lucidus*. Despite the host-range expansion by *T. sinensis* in Italy, no impact on the distribution or abundance of non-target hosts was detected or expected (Ferracini *et al*., 2017).

A comprehensive analysis of the native oak gall wasp fauna has identified 24 species that could be attacked by *T. sinensis* in the UK (see section 1.05). However, the incidence is likely to be very low (only 0.01% of adult chalcids reared from non-target galls in Italy were *T. sinensis*) and the impact minimal. There is a medium degree of uncertainty regarding the non-target effects as the population of *D. kuriphilus* is much lower in the UK than in Italy.

Minimal, minor, moderate, major, massive

Level of uncertainty:	Low	Medium X	High

6.09.0B What is the risk that the host range of the BCA includes native species in the PRA area?

Native oak gall wasps are likely to be attacked by *T. sinensis*. However, the incidence is likely to be very low and the impact minimal. These is no evidence that *T. sinensis* will attack galls on plants other than sweet chestnut and oak, although this possibility cannot be ruled out entirely. There is a medium degree of uncertainty regarding the non-target effects as the population of *D. kuriphilus* is much lower in the UK than in Italy.

Minimal, minor, moderate, major, massive

Level of uncertainty:	Low	Medium X	High

6.09.0C What is the level of damage likely to be caused by the organism on its major native hosts in the RA area?

The incidence of parasitism of native species observed in Italy was very low. There is a medium degree of uncertainty regarding the non-target effects as the population of *D. kuriphilus* is much lower in the UK than in Italy.

Minimal, minor, moderate, major, massive

Level of uncertainty:	Low X	Medium	High

6.09.0D What is the ecological importance of the host species in the PRA area?

The native oak-galling wasps are an important component of the British fauna. These is no evidence that *T. sinensis* will attack galls on plants other than sweet chestnut and oak, although this possibility cannot be ruled out entirely.

Minimal, minor, moderate, **major**, massive

Level of uncertainty:	Low	Medium X	High

6.09.0E To what extent do the host species occur in ecologically sensitive habitats (includes all officially protected nature conservation habitats)?

Sweet chestnuts and *D. kuriphilus* galls are found in nature reserves and protected sites so *T. sinensis* may also occur in these sites. However, *T. sinensis* may be beneficial by supressing an alien invasive gall wasp.

Minimal, minor, moderate, major, massive

Level of uncertainty:	Low X	Medium	High

6.09.0F What is the risk that the pest would harm rare or vulnerable species (includes all species classified as rare, vulnerable or endangered in official national or regional lists within the PRA area)?

Torymus sinensis has been reared from 11 species of non-target gall-wasps, all on oak. Only one of these is considered rare in the UK, the Hedgehog gall (*Andricus lucidus* (Hartig). This is a Mediterranean species that was first recorded in the UK in the 1990s and has since spread widely. It occurs over a much wider area than *T. sinensis* is likely to establish. There is no evidence that *Torymus sinensis* will have any effect on rare or vulnerable species in the UK.

Minimal, minor, moderate, major, massive

Level of uncertainty:	Low X	Medium	High

6.09.0G What is the risk that the presence of the BCA would result in an increased and intensive use of pesticides?

None.

Minimal, minor, moderate, major, massive

Level of uncertainty:	Low X	Medium	High

6.09.0H To what extend does the pest hybridize with native species?

In Japan, laboratory studies indicate that the introduced parasitoid *T. sinensis* is able to mate with the indigenous *T. beneficus* resulting in morphologically intermediate, fertile female offspring (Moriya *et al*., 2003). Further details on this hybridisation are provided in section 2.02. Could hybridization occur between the 50+ species of *Torymus* found in UK and *T. sinensis*? As mentioned previously, behavioural experiments have confirmed high levels of mating specificity (Quacchia *et al.*, 2014) which suggests that interbreeding with native

Torymus species is highly unlikely. No evidence of hybridization has been found in Italy or elsewhere in Europe.

Minimal, minor, moderate, major, massive

Level of uncertainty:	**Low**	**Medium X**	**High**

6.09.0I To what extent does the BCA cause physical modifications of habitats (e.g. changes to the hydrology, significant increase of water turbidity, light interception, alteration of river banks, changes in fire regie, etc.)?

None.

Minimal, minor, moderate, major, massive

Level of uncertainty:	**Low X**	**Medium**	**High**

6.09.0J To what extent does the BCA cause changes in nutrient cycling and availability (e.g. significant changes in nutrient pools in topsoils or in water)?

None.

Minimal, minor, moderate, major, massive

Level of uncertainty:	**Low X**	**Medium**	**High**

6.09.0K To what extent does the BCA cause modification of natural successions (e.g. acceleration or temporary freezing of successions)?

None.

Minimal, minor, moderate, major, massive

Level of uncertainty:	**Low X**	**Medium**	**High**

6.09.0L To what extent does the BCA disrupt trophic and mutualistic interactions (e.g. disruption of food web, pollination or plant-mycorrhiza webs leading to ecosystem imbalance)?

There is no evidence that *T. sinensis* has disrupted trophic and mutualistic interactions in Italy, other than causing a significant reduction in the density of *D. kuriphilus* galls. There is a low level of non-target effects on native oak galls, but this appears to have a far lower impact that the parasitism caused by native parasitoids.

Minimal, minor, moderate, major, massive

Level of uncertainty:	Low X	Medium	High

SOCIAL IMPACT

6.10 How important is social damage caused by the pest within its current area of distribution?

Note: Social effects are impacts on human well-being, other than economic impacts. The main social effects are:

- Landscape effects. To assess the impacts on the landscape two elements, need to be involved:
  - Land use function (agriculture, living area)
  - Contribution to wellbeing (aesthetic value, (cultural-) historic value)
- Loss of employment
- Effects on human health (in addition to effects on plant health)
- Products and services such as water quality, animal grazing, hunting and fishing (in addition to effects on plant health).
- Effects on human or animal health, the water table and tourism could be considered, as appropriate, by other agencies/authorities.

There are no reports of negative social impact.

minimal, minor, moderate, major, massive

Level of uncertainty:	Low X	Medium	High

6.11 How important is social damage likely to be in the PRA area?

There is no evidence that *T. sinensis* would have any negative social impact, such as the extinction of a native gall-forming species. In fact, the social impact is likely to be positive as the plant protection services would be seen to be trying to protect the sweet chestnuts. *Torymus sinensis* can also have a positive social impact by reducing the numbers of galls which at high densities can disfigure the tree and lower its amenity value when grown in public parks.

minimal, minor, moderate, major, massive

Level of uncertainty:	Low X	Medium	High

OTHER ECONOMIC IMPACTS

6.12 To what extent is the pest likely to disrupt existing biological or integrated systems for control of other pests?

Negligible.

Minimal extent, minor extent, moderate extent, major extent, massive extent

Level of uncertainty:	Low X	Medium	High

6.13 How great an increase in other costs resulting from introduction is likely to occur?

Note: This is evaluated in comparison with total production costs, see q. 6.05. Other costs include costs to the government, such as project management and administration, enforcement, research, extension/education, advice, publicity, certification schemes; costs to the crop protection industry.

There are likely to be additional costs for the government with keeping the public informed, providing advice, education, project management and administration, surveying and efficacy assessments.

minimal, **minor**, moderate, major, massive

Level of uncertainty:	Low X	Medium	High

6.14 How great an increase in the economic impact of other pests is likely to occur if the BCA can act as a vector or host for these pests or if genetic traits can be carried to other species, modifying their genetic nature?

Torymus sinensis is not a known vector.

minimal, minor, moderate, major, massive

Level of uncertainty:	Low X	Medium	High

Conclusion of the assessment of economic consequences

6.15a – describe the overall economic / environmental / social impacts

There are no negative economic or social impacts expected.

There are likely to be positive economic consequences as suppression of the *D. kuriphilus* populations may lower the risk of the gall wasp reducing foliage area and affecting branch architecture (killing terminal buds causing lateral branching, and causing right-angle bends in stem growth), which is detrimental to the quality of coppice grown for fencing. *Dryocosmus kuriphilus* has been reported to cause significant alterations in branch architecture and leaf area losses exceeding 70% in Switzerland (Gehring et al., 2018).

A Cost Benefit Analysis has shown that the Net Present Value (NPV) benefits generated by the *T. sinensis* release programme are in the form of non-market benefits that are recovered following *T. sinensis* parasitism of *D. kuriphilus* (Audsley *et al*., 2017). In total, non-market benefits to the value of £837,231 are realised by the programme, while a recovery in timber yield adds a further £79,181 in benefits. Combining the benefits and estimated costs of the *T. sinensis* release programme, results in a NPV net benefit of £378,769 and an associated cost-benefit ratio of 0.59. This indicates the release programme provides value for money as the benefits of a recovery in the yield and non-market benefits of sweet chestnut trees outweighs the programmes outlays.

However, there are many uncertainties and data gaps that surround the cost-benefit analysis. One issue relates to the British climate and density of sweet chestnut trees in the UK, which makes it difficult to foresee the nature of *D. kuriphilus* and *T. sinensis* spread in the UK. For instance, how is a relatively fragmented distribution of sweet chestnut in the UK expected to affect the spread of *D. kuriphilus*, and how will this distribution affect possible dynamics (such as 'predator-prey' dynamics) between *D. kuriphilus* and *T. sinensis*? The cost-benefit analysis partly overcame this issue by conducting a sensitivity analysis into the rate of *D. kuriphilus* spread, although it is difficult to see how the spread dynamics can be accurately foreseen given the fragmented distribution of sweet chestnut. Another issue relates to the susceptibility of *D. kuriphilus* infected trees to infection from diseases like chestnut blight. Ideally it would be useful to include the cost of these secondary infections in the framework of the cost-benefit analysis, but developing the methodology (such as attributions factors) would be complex.

Torymus sinensis may have a negative environmental impact by parasitizing native oak-galling wasps, but the incidence is likely to be so low that the impact will be negligible.

6.15b With reference to the area of potential establishment identified in Q 3.08, identify the areas which are at highest risk from economic, environmental and social impacts. Summarize the impacts and indicate how these may change in future.

The RA area is the area in the UK where *D. kuriphilus* has the potential to establish, which is restricted by the distribution of its only host, sweet chestnut *Castanea sativa*. There are no high-risk areas from economic, environmental and social impacts.

minimal, minor, moderate, major, massive

Level of uncertainty:	Low X	Medium	High

Degree of uncertainty

Estimation of the probability of introduction of a pest and of its economic consequences involves many uncertainties. In particular, this estimation is an extrapolation from the situation where the pest occurs to the hypothetical situation in the PRA area. It is important to document the areas of uncertainty (including identifying and prioritizing of additional data to be collected and research to be conducted) and the degree of uncertainty in the assessment, and to indicate where expert judgement has been used. This is necessary for transparency and may also be useful for identifying and prioritizing research needs.

It should be noted that the assessment of the probability and consequences of environmental hazards of pests of uncultivated plants often involves greater uncertainty than for pests of cultivated plants. This is due to the lack of information, additional complexity associated with ecosystems, and variability associated with pests, hosts or habitats.

Key areas of uncertainty

Efficacy of *T. sinensis* in the UK.	Proxy data was obtained from the release of *T. sinensis* in Japan (Moriya *et al*., 2003).	High. Differences between Japan and the UK, in terms of the density of sweet chestnut, climate, *D. kuriphilus* population levels, overwintering survival of *T. sinensis* in galls on the ground, and hyper-parasitism make the efficacy of *T. sinensis* in the UK uncertain.
Non-target effect of *T. sinensis* in the UK.	Proxy data was obtained from the release of *T. sinensis* in Italy (Ferracini *et al*., 2015 and 2017).	High. Differences between the native oak galling fauna in the UK compared with Italy.
Cost of *T. sinensis* release programme.	Data required was obtained from R. Shaw, pers. comm based on experience of similar release programmes.	Low.

Conclusion of the pest risk assessment

Establishment

Evaluate the probability of establishment, and indicate the elements which make establishment most likely or those that make it least likely. Specify which part of the PRA area presents the greatest risk of establishment.

Climatic modelling indicates it should be possible for *T. sinensis* to establish self-sustaining biocontrol populations in South-East England where *D. kuriphilus* occurs. Factors that may interfere with establishment include the relatively low density of sweet chestnuts, low density of *D. kuriphilus* galls, mortality of *T. sinensis* in galls overwintering on the ground, the effect of climate on synchronization between the gall formation and *T. sinensis* adult emergence, and effects of hyper-parasitism.

Spread

Evaluate the probability of spread, and indicate the elements which make spread most likely or those that make it least likely.

The potential rate of spread of *T. sinensis* in the RA area is expected to be lower than reported in Italy and Japan due to lower summer temperatures, potentially higher winter mortality as a greater proportion of galls overwintering on the ground, and much lower gall/host density. It is anticipated that *T. sinensis* will have a moderate to high rate of spread with a high degree of uncertainty.

Economic, environmental and social importance

List the most important potential economic impacts, and estimate how likely they are to arise in the PRA area. Specify which part of the PRA area is economically most at risk.

There are no expected negative economic or social consequences resulting from the introduction of *T. sinensis*. Suppression of the *D. kuriphilus* populations may have an economic benefit by reducing the risk of the gall wasp killing the terminal buds and causing lateral branching which reduces the quality of coppice grown for fencing. It may also help mitigate the impact of chestnut blight, a regulated disease recently found in England, by reducing the *D. kuriphilus* populations which provide an entry point for the fungus to attack sweet chestnuts. A Cost Benefit Analysis indicates the release programme provides value for money as the benefits of a recovery in the yield and non-market benefits of sweet chestnut trees outweighs the programmes outlays by a ratio of 0.59. *Torymus sinensis* may have some negative environmental impact by parasitizing native oak-galling wasps but the incidence is likely to be so low that the consequences will be negligible.

Overall conclusion of the pest risk assessment

The risk assessors should give an overall conclusion on the pest risk assessment.

The Oriental chestnut gall wasp *Dryocosmus kuriphilus* is the most damaging insect pest of chestnut species (*Castanea* spp.) worldwide (Down & Audsley, 2016). This invasive alien species has established in southern England since at least 2014 and the only effective management option is classical biological control using the invertebrate biological control agent (BCA) *Torymus sinensis*. This method has been used to successfully control *D. kuriphilus* in Croatia, France, Hungary, Italy, Japan, Portugal, Slovenia, Spain, Turkey, and the USA. For example, it has proved to be highly successful in northern Italy reducing *D. kuriphilus* infestation rates to almost zero, nine-years after the release of the parasitoid, and in southern Italy it produced a drastic reduction of *D. kuriphilus* in Campania within only 5 years (Cascone *et al*., 2018). This Risk Assessment for the BCA shows that the risks and potential negative consequences of releasing *T. sinensis* in the UK are low. The positive environmental impacts (suppression of the *D. kuriphilus* populations may help reduce the spread of chestnut blight) expected from the release of *T. sinensis* in the UK is likely to outweigh any potential negative impacts such as non-target effects.

It is therefore recommended that *T. sinensis* is used for the management of *D. kuriphilus* in the UK and its establishment, efficacy and environmental impact be monitored. This will provide invaluable data for future potential introductions of BCAs in the UK.

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List of Appendices

Appendix 1. Climate modelling for *Torymus sinensis*