Risk assessment template developed under the "Study on Invasive Alien Species – Development of risk assessments to tackle priority species and enhance prevention"
Contract No 07.0202/2018/788519/ETU/ENV.D.2[1]

Name of organism: ***Pycnonotus cafer*** **(Linnaeus, 1766), red-vented bulbul**

Author(s) of the assessment:

- *Yasmine Verzelen, Institute for Nature and Forest Research (INBO), Brussels, Belgium*
- *Tim Adriaens, Institute for Nature and Forest Research (INBO), Brussels, Belgium*
- *Riccardo Scalera, IUCN SSC Invasive Species Specialist Group, Rome, Italy*
- *Björn Beckmann, Centre for Ecology and Hydrology (CEH), Wallingford, United Kingdom*
- *Martin Thibault, Institut de Recherche pour le Développement, Nouméa, New Caledonia*
- *Peter Robertson, Newcastle University, United Kingdom*
- *Marianne Kettunen, Institute for European Environmental Policy (IEEP), London, United Kingdom*
- *Sven Bacher, Department of Biology, Ecology & Evolution Unit, University of Fribourg, Switzerland*
- *Wolfgang Rabitsch, Umweltbundesamt, Vienna, Austria*

Risk Assessment Area: The risk assessment area is the territory of the European Union 27 and the United Kingdom, excluding the outermost regions of the EU.

Peer review 1: *Tom Evans, Institute of Biology, Free University of Berlin & Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB), Berlin, Germany*

Peer review 2: *Jørgen Eilenberg, University of Copenhagen, Plant and Environmental Sciences, Denmark*

Acknowledgments: we thank Giuseppe Brundu and Rob Tanner (EPPO) for information on alien and invasive plants in the Mediterranean. We are grateful to Keith Bensusan (Gibraltar Botanic Gardens) and Carlos Gutiérrez-Expósito (Estación Biológica de Doñana) for information on the status of the species in southern Spain. We thank Iolanda Rocha (CIBIO-InBIO) for providing information on the status of reptiles on Mediterranean islands.

Date of completion: 31 October 2019

Date of revision: 4 March 2021

Positive opinion by the Scientific Forum: 13 April 2021

[1] This template is based on the Great Britain non-native species risk assessment scheme (GBNNRA). A number of amendments have been introduced to ensure compliance with Regulation (EU) 1143/2014 on IAS and relevant legislation, including the Delegated Regulation (EU) 2018/968 of 30 April 2018, supplementing Regulation (EU) No 1143/2014 of the European Parliament and of the Council with regard to risk assessments in relation to invasive alien species (see https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32018R0968).

Contents

SECTION A – Organism Information and Screening

A1. Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?
including the following elements: ● the taxonomic family, order and class to which the species belongs; ● the scientific name and author of the species, as well as a list of the most common synonym names; ● names used in commerce (if any) ● a list of the most common subspecies, lower taxa, varieties, breeds or hybrids As a general rule, one risk assessment should be developed for a single species. However, there may be cases where it may be justified to develop one risk assessment covering more than one species (e.g. species belonging to the same genus with comparable or identical features and impact). It shall be clearly stated if the risk assessment covers more than one species, or if it excludes or only includes certain subspecies, lower taxa, hybrids, varieties or breeds (and if so, which subspecies, lower taxa, hybrids, varieties or breeds). Any such choice must be properly justified.

Response:

The red-vented bulbul belongs to the class Aves, order Passeriformes, family Pycnonotidae. The scientific name for the red-vented bulbul is *Pycnonotus cafer*, and the author is Linnaeus, 1766. Earlier names include *Turdus cafer* (Linnaeus, 1766), *Molpastes haemorrhous* (J.F. Gmelin, 1789), *Pycnonotus pygaeus* (Sharpe, 1881) and *Molpastes cafer* (Baker, 1930). Other names for the species in English and in other languages include common bulbul or sooty-headed bulbul (Thibault, 2018a), bulbul ventirrojo (ES), Bulbul à ventre rouge (FR), Rußbülbül (DE), Kala buulbuul (NL), roodbuikbuulbuul (NL) and Bilbil czerwonoplamy (PL).

The genus *Pycnonotus* comprises 49 species (Delacour, 1943; Dickinson and Dekker, 2002; Gill et al., 2021).

Pycnonotus cafer comprises eight subspecies (Dickinson et al., 2002):

- Central Indian red-vented bulbul (*P. c. humayuni* Deignan, 1951), found in south-eastern Pakistan, north-western and north-central India;
- Punjab red-vented bulbul (*P. c. intermedius* Blyth, 1846), in Kashmir, Kohat down to the Salt Range and along the western Himalayas to Kumaon, originally described as a separate species;
- *P. c. bengalensis* (Blyth, 1845), in central and eastern Himalayas from Nepal to Assam, north-eastern India and Bangladesh, originally described as a separate species;
- *P. c. stanfordi* (Deignan, 1949), in northern Burma and south-western China;
- *P. c. melanchimus* (Deignan, 1949), in south-central Burma and northern Thailand;
- *P. c. wetmorei* (Deignan, 1960), in eastern India;
- *P. c. cafer* (Linnaeus, 1766), in southern India;
- *P. c. haemorrhousus* (Gmelin, 1789), in Sri Lanka (Dickinson et al., 2002).

In its native range, *P. c. humayuni* is known to hybridize with *Pycnonotus leucogenys* (Gray, 1835). These hybrids were once described as subspecies *magrathi* (Sibley & Short, 1959). Hybridisation with

Pycnonotus leucogenys has also been observed in the United Arab Emirates (Khan, 1993) and Bahrain (Khamis, 2010). The offspring of hybrids in Bahrain is believed to be sterile (Khamis, 2010). In Myanmar, there is some natural hybridization with *Pycnonotus aurigaster* (Sharpe, 1909; Rasmussen & Anderton, 2005), with hybrids formerly considered as the subspecies *P. c. burmanicus* and *P. c. nigropileus* (Dickinson et al. 2002; Dickinson & Dekker 2002). Hybridisation with *Pycnonotus leucotis* (Gould, 1836) has been observed in Kuwait (Gregory, 2005), Qatar (Nation et al., 1997) and Iran (Azin et al., 2008). Hybridisation with *Pycnonotus xanthopygos* (Hemprich & Ehrenberg, 1833) has been observed in the United Arab Emirates (Khan, 1993).

A2. Provide information on the existence of other species that look very similar [that may be detected in the risk assessment area, either in the environment, in confinement or associated with a pathway of introduction]

Include both native and non-native species that could be confused with the species being assessed, including the following elements:

- other alien species with similar invasive characteristics, to be avoided as substitute species (in this case preparing a risk assessment for more than one species together may be considered);
- other alien species without similar invasive characteristics, potential substitute species;
- native species, potential misidentification and mis-targeting

Response:

Pycnonotus cafer has brown feathering and a black crest on its head, neck and throat (Thibault, 2018a; Pratt et al., 1987). Its sub-caudal feathers have a bright crimson colour, hence the species' name (Berger, 1981; Zia et al., 2014). It has a pale greyish white lower belly and rump which is highly visible in flight, and a long tail with a white tip (Zia et al., 2014). The tips of the back and breast feathers are white and this light edging gives them a scaly appearance (Thibault, 2018a). The tail is black with a narrow white tip (Thibault, 2018a). The red-vented bulbul measures about 21 cm in length (Berger, 1972) and its weight can vary from 26 to 45 grams (Long, 1981). Males can measure up to 23 cm in length, slightly larger than females, which is the only sexual dimorphism in the red-vented bulbul (Stuart & Stuart, 1999). Juveniles look like adults but with paler feathering and brownish edging on the feathers (Thibault, 2018a). It may live for up to 11 years in captivity (Walker, 2008).

The red-whiskered bulbul (*P. jocosus*) or crested bulbul, has been introduced to many regions of the world, including in Europe (Spain). The red-whiskered bulbul has an erect black/dark brown crest, a dark brown/black head with prominent white cheek patches and red whiskers below each eye. It is widely kept as a cage bird, escaped and established in many places, including Australia, Madagascar, Hawaii, Japan, the Seychelles, the USA and Spain. It is a pest of agriculture and gardens, feeding on fruits, vegetables, flower buds and insects. Furthermore, it is known to have environmental impacts through the dispersal of seeds of invasive plants, interspecific competition and predation on geckos and invertebrates (Hawaii Invasive Species Council, 2017; Cottrell, 2017).

In Europe, both the red-vented bulbul and the red-whiskered bulbul are established sympatrically in Valencia, Spain (Lever, 2015; Dyer et al., 2017), so it is possible that one species could be confused for the other in this region. Another alien species physically resembling the red-vented bulbul is the sooty-headed bulbul (*P. aurigaster*), mostly because of its red vent and black head. However, the breast and belly of *P. aurigaster* is lighter and only birds of the *chrysorrhoides* group have a red vent (Fishpool & Tobias, 2019). The sooty-headed bulbul is one of the most abundant and widespread native bulbuls on Java and Bali. It has been introduced to Sumatra, Singapore and Borneo where its alien populations have been expanding since the 1980s. It is suggested that this spread can be attributed to escaped birds from captivity (Phillipps & Phillipps, 2011). However, the species currently has no known alien populations in Europe. Hybrids between red-vented and sooty-headed bulbul do occur and can be difficult to identify (see A1). The only other bulbul with a known alien population is the yellow-vented bulbul (*P. goiavier*), which is native to the Malay Peninsula, Borneo, Thailand and the Philippines, and has an alien population on Sulawesi (Lever, 2005). However, the yellow-vented bulbul does not possess similar physical characteristics to the red-vented bulbul.

The only native species that somewhat resembles the red-vented bulbul and that therefore could be misidentified as such is the common bulbul (*P. barbatus*). This species is one of the commonest birds in Africa but is very rare in the wild in the risk assessment area. In recent years, common bulbul has bred in Tarifa (Cádiz, Andalusia, Spain) in an area that is potentially suitable for the red-vented bulbul as well. Birds are still present in the area, but only one pair has been known to breed and its status in Europe is currently tenuous (personal communication K. Bensusan, 22/10/2019). In 2013, two adult common bulbuls were observed feeding a young, which represented the first breeding record for the species in Europe (van den Berg & Haas, 2013).

A3. Does a relevant earlier risk assessment exist? Give details of any previous risk assessment, including the final scores and its validity in relation to the risk assessment area.

Response:

No other risk assessments for the species were found. However, as a well-known invader listed on the IUCN/ISSG list of 100th of the worst invasive species (Lowe et al., 2004), the species was included in several scoring exercises of invasive bird impacts globally. The results of these exercises are discussed in Qu. 5.1. An assessment of the impacts of the red-vented bulbul, undertaken using the Environmental Impact Classification for Alien Taxa (EICAT) classified the species as having Moderate (MO) impacts[2] through competition with native birds and by spreading the seeds of alien plants (Evans et al., 2016). The red-vented bulbul is also listed in the DAISIE database, however without any specific assessment.

A4. Where is the organism native?

including the following elements:

[2] EICAT categories are, from low to high impact: Minimal Concern (MC), Minor (MN), Moderate (MO), Major (MR), Massive (MV). MO impacts cause declines in populations of native species but do not cause native species extinctions.

- an indication of the continent or part of a continent, climatic zone and habitat where the species is naturally occurring
- if applicable, indicate whether the species could naturally spread into the risk assessment area

Response:

Pycnonotus cafer is native to the Indian Subcontinent, Southeast Asia, and Malay Peninsula (Long, 1981). It occurs naturally from Eastern Pakistan to southern China and Vietnam, and from Northern India to Sri Lanka. The species is linked to an equatorial climate according to the Kopper-Geigen classification (Kottek et al., 2006) and can live in diverse habitat types. The species is found in open areas, dry scrub, plains, cropland, natural forests, forest edges as well as plantations and prefers anthropogenic environments (urban areas, gardens, parks, farms) (Vander Velde, 2002). In India, the species is used for bulbul fighting, a traditional yet recently prohibited custom at harvest festivals (Ratnagar, 2015).

A5. What is the global non-native distribution of the organism outside the risk assessment area?

Response:

According to Thibault et al. (2018c), *Pycnonotus cafer* was introduced into 18 countries and established in 17 of them. The species is now present on at least 37 islands and seven continental locations (Thibault et al., 2018c). In order of first detection the countries where red-vented bulbul was introduced are: Fiji, Australia (extinct), Tonga, the Independent State of Samoa, New Zealand (eradicated), American Samoa, USA (Hawaii, Texas), Qatar, United Arab Emirates, French Polynesia, Saudi Arabia, Kuwait, New Caledonia, Bahrain, Oman, Spain (mainland Spain and Fuerteventura - Canary Islands), the Marshall Islands and Iran (Thibault et al., 2018c).

The first record of the red-vented bulbul outside of its native range was in Fiji in 1903 (Parham, 1955) where the species established and colonised several islands (Thibault et al., 2018c). It was probably brought there by Indian immigrants in the early 1900s (Watling, 1978), as it was widely used in bird fights in India because of its aggressive behaviour (Ali & Ripley, 1971). The bird has been recorded 6100 times in eight Pacific archipelagos since this first detection (Thibault 2018a).

The red-vented bulbul was detected in Melbourne and Sydney, Australia in 1918 and again in Melbourne in 1942 (Lendon, 1952; Watling, 1978; Dyer et al., 2017). Although a small population persisted for some time in the suburbs of Melbourne since 1918 (Watling 1978), it did however not successfully establish in Australia (Thibault et al., 2018c). The subspecies *P. c. bengalensis* was found in Melbourne in 1982 (Dyer et al., 2017). There are no records of the species since then. It is considered to be eradicated in Australia (http://www.issg.org/database).

The red-vented bulbul was deliberately introduced in the 1940s in Tonga to control unwanted insects (Watling, 1978). The red-vented bulbul probably reached the Independent State of Samoa in the early 1950's, and has since spread to several islands in the archipelago (Dhondt, 1977). The first observation of red-vented bulbul in Auckland, New Zealand was in 1952, but the species was eradicated in 1955

(Turbott, 1956; Watling, 1978). The red-vented bulbul was introduced in American Samoa in the late 1950s and quickly became established (Clapp & Sibley 1966; Freifeld, 1999). First observations for Hawaii (USA) date from 1966. In French Polynesia, the red-vented bulbul was first noticed in the residential area of Papeete in 1979. They are now common on Tahiti on elevations of up to 1000 m, possibly having negative interactions with the Tahiti monarch (*Pomarea nigra*) (Blanvillain et al., 2003). The species was intentionally released in Nouméa (New Caledonia) around 1983 by bird dealers to avoid prosecution (Thibault et al., 2018c). The red-vented bulbul was first sighted on the Marshall Islands in 2000, near the major commercial dock of Majuro, and was known to hitchhike on ships to other areas of the archipelago. In 2002, there were already several breeding populations (Vander Velde, 2002). Several individuals were seen by Christina Sylvester on the Kwajalein Atoll in November 2018 (http://www.underwaterkwaj.com/land/bird-kwaj/bird-kwaj.htm, visited on 07/06/2019).

In the Middle East, the red-vented bulbul was first detected in Qatar in 1971 (Nation et al., 1997). It has been reported 3080 times in five countries around the Persian Gulf since this first detection. The red-vented bulbul was first detected in the United Arab Emirates in 1974 where it is now common and expanding (Pedersen & Aspinall, 2010), and was first detected in Saudi Arabia in the 1980s (personal communication J. Babington). In Kuwait, the red-vented bulbul was first observed in 1981, and it is currently scarce, with a declining range (Gregory, 2005). According to Khamis (2010), the red-vented bulbul was first recorded in Bahrain in 1986, likely following an escape. At present, the bird maintains a self-sustaining population here. The first observation in Oman dates from 1987 and the red-vented bulbul is now a common bird there (Thibault et al., 2018a). In Iran, the red-vented bulbul was first recorded in 2007 when 10-12 individuals were observed in the east of Kish Island, Hormozgan Province (Azin et al., 2008).

The red-vented bulbul was first observed in Houston (Texas, USA) near the end of the 1990's. At least 14 sightings were reported between May 1999 and March 2004. These sightings have been estimated to represent 32 birds at 10 sites in Houston (Eubanks et al., 2006).

A population is also established on Fuerteventura (Canary Islands, Spain) with the first sightings in the late 1990s. By 2017, the species had spread over the entire island (SEO/Birdlife 2017; Nowakowski and Dulisz 2019).

A6. In which biogeographic region(s) or marine subregion(s) in the risk assessment area has the species been recorded and where is it established? The information needs be given separately for recorded and established occurrences.

A6a. Recorded: List regions

A6b. Established: List regions

Freshwater / terrestrial biogeographic regions:

- Alpine, Atlantic, Black Sea, Boreal, Continental, Mediterranean, Pannonian, Steppic

Marine regions:

- Baltic Sea, North-east Atlantic Ocean, Mediterranean Sea, Black Sea

Marine subregions:

- Greater North Sea, incl. the Kattegat and the English Channel, Celtic Seas, Bay of Biscay and the Iberian Coast, Western Mediterranean Sea, Adriatic Sea, Ionian Sea, Central Mediterranean Sea, Aegean-Levantine Sea.

Comment on the sources of information on which the response is based and discuss any uncertainty in the response.

For delimitation of EU biogeographical regions please refer to https://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-in-europe-2 (see also Annex V).

For delimitation of EU marine regions and subregions consider the Marine Strategy Framework Directive areas; please refer to https://www.eea.europa.eu/data-and-maps/data/msfd-regions-and-subregions/technical-document/pdf (see also Annex V).

Response (6a): Mediterranean, Atlantic

In the Netherlands, there have been multiple sightings of individual birds in the wild since 1999 (Avifauna Groningen, 2000; waarneming.nl). A number of these birds were sighted in the middle of urban areas suggesting an escaped origin. In Belgium, there was one observation of an escape in a natural area in a military Domain in 2005 (Brecht, Antwerp province). There are probably many more unreported incidental records of escaped birds across the risk assessment area. In Spain, there are some observations in Málaga and Torremolinos (personal communication A. Paterson).

Response (6b): Mediterranean

In Valencia (Spain), the species seems to be established, but no research has targeted this species yet. Breeding was observed in 2017 in gardens of urbanized areas surrounding the city. The range is not big, but they seem to be fairly common. There, the species is sympatric with the well-established red-whiskered bulbul (*P. jocosus*). (https://www.miteco.gob.es/es/biodiversidad/temas/inventarios-nacionales/; personal communication C. Gutiérrez-Expósito, 12/12/2018).

A7. In which biogeographic region(s) or marine subregion(s) in the risk assessment area could the species establish in the future under current climate and under foreseeable climate change? The information needs to be given separately for current climate and under foreseeable climate change conditions.

A7a. Current climate: List regions

A7b. Future climate: List regions

With regard to EU biogeographic and marine (sub)regions, see above.

With regard to climate change, provide information on

- the applied timeframe (e.g. 2050/2070)
- the applied scenario (e.g. RCP 4.5)
- what aspects of climate change are most likely to affect the risk assessment (e.g. increase in average winter temperature, increase in drought periods)

The assessment does not have to include a full range of simulations on the basis of different climate change scenarios, as long as an assessment with a clear explanation of the assumptions is provided. However, if new, original models are executed for this risk assessment, the following RCP pathways shall be applied: RCP 2.6 (likely range of 0.4-1.6°C global warming increase by 2065) and RCP 4.5 (likely range of 0.9-2.0°C global warming increase by 2065). Otherwise, the choice of the assessed scenario has to be explained.

Response (7a): Mediterranean

According to the species distribution model (SDM, Annex VII), the red-vented bulbul could potentially establish in the Mediterranean biogeographical region. However, only around 2% of this bioregion is predicted to be suitable under current climatic conditions.

Response (7b): Mediterranean.

Under climate change scenarios RCP 2.6 and RCP 4.5, only the Mediterranean biogeographical region is deemed suitable for the establishment of *P. cafer*. The proportion of the region predicted to be suitable increases under both RCP scenarios, to 4% under RCP 2.6 and 6% under RCP 4.5.

A8. In which EU Member States has the species been recorded and in which EU Member States has it established? List them with an indication of the timeline of observations. The information needs be given separately for recorded and established occurrences.

A8a. Recorded: List Member States

A8b. Established: List Member States

Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden

The description of the invasion history of the species shall include information on countries invaded and an indication of the timeline of the first observations, establishment and spread.

Response (8a): Spain, Belgium, The Netherlands

In the province of Málaga (Spain), breeding was observed in 2001 and 2002, however, it seems that the red-vented bulbul is not established there anymore. The last documented sighting of red-vented bulbul in Málaga province dates back to 2007. In Torremolinos (Málaga), a group of birds was observed in 1998, 2001 and 2002 (personal communication A. Paterson). On November 9, 2000, three individuals were observed singing and on May 27, 2001, a couple copulating. On 7 July 2002, four specimens were observed, of which two were juveniles. On September 9, 2002, a second clutch was confirmed, and the pair was observed with a chick, indicating the species successfully established in this area. However, there are no indications red-vented bulbul is currently still established around Torremolinos (https://www.miteco.gob.es/es/biodiversidad/temas/inventarios-nacionales/).

In Belgium, the red-vented bulbul was observed in August 2005 in the province of Antwerp (http://waarnemingen.be/waarneming/view/41885488). This is the only known observation for Belgium.

In the Netherlands, the red-vented bulbul was observed on five occasions, in September and October of 2006, and in July 2009 (https://data.biodiversitydata.nl/obsint/observation/OBS.44081179).

Response (8b): Spain

In Valencia (Valencia, Spain), the species seems to be established, as breeding was observed in 2017 when a family group of bulbuls were seen in urban gardens surrounding the city (personal communication C. Gutiérrez-Expósito, 12/12/2018). Their range is small, but they are not uncommon. The species is sympatric with a well-established red-whiskered bulbul (*P. jocosus*) population. Successful breeding of red-vented bulbul was reported in 2002 around Torremolinos but there, the last sighting was performed in 2007 (see above).

A9. In which EU Member States could the species establish in the future under current climate and under foreseeable climate change? The information needs to be given separately for current climate and under foreseeable climate change conditions.

A9a. Current climate: List Member States

A9b. Future climate: List Member States

With regard to EU Member States, see above.

With regard to climate change, provide information on

- the applied timeframe (e.g. 2050/2070)
- the applied scenario (e.g. RCP 4.5)
- what aspects of climate change are most likely to affect the risk assessment (e.g. increase in average winter temperature, increase in drought periods)

The assessment does not have to include a full range of simulations on the basis of different climate change scenarios, as long as an assessment with a clear explanation of the assumptions is provided. However, if new, original models are executed for this risk assessment, the following RCP pathways shall be applied: RCP 2.6 (likely range of 0.4-1.6°C global warming increase by 2065) and RCP 4.5 (likely range of 0.9-2.0°C global warming increase by 2065). Otherwise, the choice of the assessed scenario has to be explained.

Response (9a): Cyprus, Spain, Greece, France and potentially other Mediterranean member states with islands (Italy, Portugal, Malta) for which the confidence on the SDM is lower. Under current climate, these countries have suitable areas for the establishment of the red-vented bulbul. Yet the suitable area represents only 2% of the Mediterranean bioregion (see 7a, Annex VII, figure 9).

Overall, the main limiting factor in most of the risk assessment area is annual mean temperature (Bio1). Since *P. cafer* is a species of subtropical climate, it is reasonable to assume that most of Europe will be too cold for successful reproduction. Second, precipitation of the wettest month

(Bio13) is the main limiting factor in some parts of southern Europe. The red-vented bulbul indeed avoids deserts and needs trees/shrubs for nesting (Zia et al., 2014), and a low precipitation of the wettest month indicates this. The ensemble model suggested that suitability for red-vented bulbul was most strongly determined by Annual mean temperature (Bio1), accounting for 43.5% of variation explained, followed by Mean temperature of the warmest quarter (Bio10) (24.7%), Precipitation of the wettest month (Bio13) (8.8%), Minimum temperature of the coldest month (Bio6) (8.3%), Annual precipitation (Bio12) (5.9%), Human influence index (HII) (5.6%), Precipitation of the driest month (Bio14) (2.3%) and Global tree cover (Tree) (0.9%). For more details, see Annex VII.

Response (9b):

RCP 2.6: Cyprus, France, Greece, Spain and potentially other Mediterranean member states with islands (Italy, Portugal, Malta) for which the confidence on the SDM is lower.

RCP 4.5: Cyprus, France, Greece, Spain and potentially other Mediterranean member states with islands (Italy, Portugal, Malta) for which the confidence on the SDM is lower.

For more details, see Annex VII.

A10. Is the organism known to be invasive (i.e. to threaten or adversely impact upon biodiversity and related ecosystem services) anywhere outside the risk assessment area?

Response:

Yes. The red-vented bulbul impacts native biodiversity outside of the risk assessment area in three ways:

1/ Frugivory: most damage relates to its diverse diet that comprises fruits and berries (Islam & Williams, 2000; Brooks, 2013), flowers, buds, insects and small reptiles (Vander Velde, 2002). It feeds on cultivated (food and ornamental) plants and is considered a problematic seed disperser of invasive alien plants, such as *Lantana camara* (Spotswood et al, 2013).

2/ Competition: its aggressive behaviour towards other birds has been reported to lead to niche contraction of some native birds (e.g. Tahiti flycatcher (*Pomarea nigra*)) in the Pacific (Blanvillain et al., 2003). Its numerical abundance was inversely correlated with the abundance of nine bird species in New Caledonia (Thibault et al., 2018d).

3/ Hybridisation: in the Middle East, crossbreeding with native bulbul species (*P. leucogenys, P. leucotis, P. xanthopygos*) threatens the genetic integrity of these native bird populations (Khan, 1993; Nation et al., 1997; Gregory, 2005; Azin et al., 2008; Khamis, 2010).

On the semi-arid island of Fuerteventura (Canary Islands, Macaronesia, Spain but outside the risk assessment area) the species was first observed in Corralejo in 2003 and expanded its range in the period 2013–2018 to cover the entire island (1.658 km^2) (SEO/Birdlife 2017; Nowakowski and Dulisz 2019). There is not a lot of habitat available to the birds on the island, and they are limited to towns and holiday resorts with gardens and parks, but also inhabit agricultural plantations. The first breeding was confirmed in 2018 around Costa Calma. The birds were observed in stands of trees in gardens of a holiday resort composed of various palm trees, fig trees, oleanders, yuccas, acacias and shrubs, and often visited the dry shrubs, typical for semi-arid vegetation of the open landscape of the island, located outside the resort's gardens (Nowakowski & Dulisz 2019).

A11. In which biogeographic region(s) or marine subregion(s) in the risk assessment area has the species shown signs of invasiveness? Indicate the area endangered by the organism as detailed as possible.

Freshwater / terrestrial biogeographic regions:

- Alpine, Atlantic, Black Sea, Boreal, Continental, Mediterranean, Pannonian, Steppic

Marine regions:

- Baltic Sea, North-east Atlantic Ocean, Mediterranean Sea, Black Sea

Marine subregions:

Greater North Sea, incl. the Kattegat and the English Channel, Celtic Seas, Bay of Biscay and the Iberian Coast, Western Mediterranean Sea, Adriatic Sea, Ionian Sea, Central Mediterranean Sea, Aegean-Levantine Sea

Response:

The red-vented bulbul is currently only present in the Mediterranean biogeographic region (Spain) within the risk assessment area (see Qu. A6b), but has not shown signs of invasiveness (see Qu. A8b).

A12. In which EU Member States has the species shown signs of invasiveness? Indicate the area endangered by the organism as detailed as possible.

Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden

Response:

The red-vented bulbul has only recently established locally in Spain and has not shown signs of invasiveness (see Qu. A.8b).

A13. Describe any known socio-economic benefits of the organism.

including the following elements:

- Description of known uses for the species, including a list and description of known uses in the Union and third countries, if relevant.
- Description of social and economic benefits deriving from those uses, including a description of

the environmental, social and economic relevance of each of those uses and an indication of associated beneficiaries, quantitatively and/or qualitatively depending on what information is available.

If the information available is not sufficient to provide a description of those benefits for the entire risk assessment area, qualitative data or different case studies from across the Union or third countries shall be used, if available.

Response:

In its native Indian range, the red-vented bulbul has been reported to feed on the cotton bollworm (*Helicoverpa armigera*), a moth that is globally considered as a major pest species because its larvae feed on a wide range of plants, including many important cultivated crops such as cotton (Rana et al., 2014, 2017).

In a cost-benefit analysis done by Daigneault & Brown (2013) on Fiji, 47% of surveyed village focus groups reported benefits of the red-vented bulbul for their community. 18% responded that it is effective at insect control, 12% noted that the red-vented bulbul sends out alarms calls when a mongoose is about to attack chickens, thereby reducing the attacks on chickens and another 12% stated that the bulbul is occasionally eaten by villagers. In addition, in the north-east of India, red-vented bulbul fights were part of a traditional and religious annual celebration, until this practice was banned in January 2016 (Shalet, 2016).

As the species is widely kept as a caged bird within and outside the risk assessment area (see A.2), it represents ornamental, sentimental and aesthetic value as a companion animal. There are no official records on trade volumes, but there are plenty of advertisements for birds online, often sold in pairs. Prices found online vary from € 165 – 250 per bird or € 250 per pair.

SECTION B – Detailed assessment

Important instructions:

- In the case of lack of information the assessors are requested to use a standardized answer: "No information has been found."
- With regard to the scoring of the likelihood of events or the magnitude of impacts see Annexes I and II.
- With regard to the confidence levels, see Annex III.
- Highlight the selected response score and confidence level in **bold** but keep the other scores in normal text (so that the selected score is evident in the final document).

1 PROBABILITY OF INTRODUCTION

Important instructions:

- **Introduction** is the movement of the species into the risk assessment area (it may be either in captive conditions and/or in the environment, depending on the relevant pathways).
- **Entry** is the release/escape/arrival in the environment, i.e. occurrence in the wild and is treated in the next section (N.B. introduction and entry may coincide for species entering through pathways such as "corridor" or "unaided)".
- The classification of pathways developed by the Convention of Biological Diversity (CBD) should be used. For detailed explanations of the CBD pathway classification scheme consult the IUCN/CEH guidance document[3] and the provided key to pathways[4].
- For organisms which are already present in the risk assessment area, only complete this section for current active pathways and, if relevant, potential future pathways.

Qu. 1.1. List relevant pathways through which the organism could be introduced. Where possible give details about the specific origins and end points of pathways as well as a description of any associated commodities.

For each pathway answer questions 1.2 to 1.7 (copy and paste additional rows at the end of this section as necessary). Please attribute unique identifiers to each question if you consider more than one pathway, e.g. 1.2a, 1.3a, etc. and then 1.2b, 1.3b etc. for the next pathway.

In this context a pathway is the route or mechanism of introduction of the species.

The description of commodities with which the introduction of the species is generally associated shall include a list and description of commodities with an indication of associated risks (e.g. the volume of trade; the likelihood of a commodity being contaminated or acting as vector).

If there are no active pathways or potential future pathways this should be stated explicitly here, and there is no need to answer the questions

1.2-1.9

[3] https://circabc.europa.eu/sd/a/738e82a8-f0a6-47c6-8f3b-aeddb535b83b/TSSR-2016-010%20CBD%20categories%20on%20pathways%20Final.pdf

[4] https://circabc.europa.eu/sd/a/0aeba7f1-c8c2-45a1-9ba3-bcb91a9f039d/TSSR-2016-010%20CBD%20pathways%20key%20full%20only.pdf

Pathway name:

a. ESCAPE from confinement: Botanical garden/zoo/aquaria (excluding domestic aquaria)
b. ESCAPE from confinement: Pet/aquarium/terrarium species (including live food for such species)
c. TRANSPORT stowaway: Hitchhikers on ship/boat (excluding ballast water and hull fouling)

Deliberate releases of red-vented bulbul for biocontrol of insect pests have also been documented in the Indo-Pacific (Watling, 1978) but these pathways of introduction are rare and considered irrelevant for the risk assessment area. Therefore they are not dealt with here (see also Qu. 2.1).

Qu. 1.2a. ESCAPE from confinement: Botanical garden/zoo/aquaria (excluding domestic aquaria)

Is introduction along this pathway intentional (e.g. the organism is imported for trade) or unintentional (e.g. the organism is a contaminant of imported goods)?

RESPONSE	**intentional** unintentional	**CONFIDENCE**	low medium **high**

Response:

Intentional because zoological gardens will intentionally buy or acquire one or more red-vented bulbul individuals to put on display.

Qu. 1.3a. How likely is it that large numbers of the organism will be introduced through this pathway from the point(s) of origin over the course of one year?

including the following elements:

- discuss how likely the organism is to get onto the pathway in the first place. Also comment on the volume of movement along this pathway.
- an indication of propagule pressure (e.g. estimated volume or number of individuals / propagules, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if relevant, comment on the likelihood of introduction based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in introduction whereas for others high propagule pressure (many thousands of individuals) may not.

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	**low** medium high

Response:

Whilst there is no data available on the total captive red-vented bulbul population within all zoological collections within the EU, information was provided by EAZA (European Association of Zoos and Aquaria) on populations kept at approximately 300 of their Member zoos and aquariums in 25 EU Member States (with the exception of Cyprus and Malta), and the United Kingdom. The information provided by EAZA (EAZA datafile 3/10/2019) indicates that the species is kept in low numbers by EAZA Member zoos in Germany, Poland, and the United Kingdom. This data comes from the animal care and management software provided by Species360 Zoological Information Management System (ZIMS) (zims.Species360.org, 2018) whose usage is widespread throughout the EAZA Membership. It must be noted that the actual situation might slightly differ if the species has been recorded under a different/older taxonomic name.

The red-vented bulbul is on display in at least the following EAZA zoos in the risk assessment area: Warsaw Zoological Garden (Poland), Köln Zoologischer Garten (Germany), Plzen Zoo (Czech Republic), Graested Nordsjællands Fuglepark (Denmark), Helsingborg Djurparken / ex. Fågelparken (Sweden), Farnham Birdworld & Underwater World (UK), Thrigby Hall Wildlife Gardens (UK) (www.zootierliste.de). EAZA is the European Association of Zoos and Aquaria and has 300 full members, 21 candidates for membership, 40 corporate members and 38 associate members as of May 2018 (www.eaza.net). This list comprises just a quarter of all zoological gardens and animal parks in Europe (www.zoos.media). Therefore, it is difficult to assess to what extent the species is kept in captivity within the risk assessment area.

Although the import of wild birds into the EU has been illegal since 2005, zoological gardens with a special zoo license can still import them. Indeed, the red-vented bulbul is present in several zoos, but it is only moderately likely that large numbers will be introduced in the zoos within the risk assessment area over the course of one year. However, no information is available as to the total number of zoos that keep red-vented bulbul, the size of the captive population nor how often these are introduced into a new zoo, so the confidence level is low.

Qu. 1.4a. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low medium **high**

Response:

If a zoo intentionally buys or acquires one or more red-vented bulbul individuals, it is very likely that these animals will survive their transport and storage along this pathway, since they are meant to stay alive. Reproduction however, is very unlikely.

Qu. 1.5a. How likely is the organism to survive existing management practices during transport

and storage along the pathway?

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	CONFIDENCE	low medium **high**

Response:

When imported legally by a zoological garden with a license, there is no reason why existing management practices would target this species. In the case of illegal import, there are no known existing management practices that target the red-vented bulbul.

Qu. 1.6a. How likely is the organism to be introduced into the risk assessment area undetected?

RESPONSE	**very unlikely** unlikely moderately likely likely very likely	CONFIDENCE	low medium **high**

Response:

The receiving zoo will always know that they are introducing the red-vented bulbul. Additionally, when on display, visitors will also detect this bird.

Qu. 1.7a. Estimate the overall likelihood of introduction into the risk assessment area based on this pathway?

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	CONFIDENCE	low medium **high**

Response:

The red-vented bulbul is already introduced in the risk assessment area, as it is present in several zoological gardens. Since zoological gardens can acquire a license to import wild birds and this species is not considered threatened, we can say with high confidence that it is very likely that the red-vented bulbul will be introduced into the risk assessment area through this pathway.

End of pathway assessment, repeat Qu. 1.3 to 1.7 as necessary using separate identifier.

Qu. 1.2b. ESCAPE from confinement: Pet/aquarium/terrarium species (including live food for such species)

Is introduction along this pathway intentional (e.g. the organism is imported for trade) or unintentional (e.g. the organism is a contaminant of imported goods)?

RESPONSE	**intentional** unintentional	**CONFIDENCE**	low medium **high**

Response:

Intentional because a person will intentionally buy the red-vented bulbul to keep as a pet even if the subsequent escape would be accidental (following IUCN 2017).

Qu. 1.3b. How likely is it that large numbers of the organism will be introduced through this pathway from the point(s) of origin over the course of one year?

including the following elements:

- discuss how likely the organism is to get onto the pathway in the first place. Also comment on the volume of movement along this pathway.
- an indication of the propagule pressure (e.g. estimated volume or number of individuals / propagules, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if relevant, comment on the likelihood of introduction based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in introduction whereas for others high propagule pressure (many thousands of individuals) may not.

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	**low** medium high

Response:

On several hobbyist websites, it is stated that the red-vented bulbul is among the most easily-kept of the softbills, which is a term applied to non-typical cage birds, such as bulbuls. The species has a confident and inquisitive nature, with a "friendly" personality towards humans, making them popular as pets. As stated in Qu. A13, there are no official records on trade volumes, but there are plenty of advertisements for birds online, often sold in pairs. Prices found online vary from € 165–250 per bird or € 250 per pair. For example, in France, red-vented bulbuls are advertised for sale online at € 250 per pair (www.leboncoin.fr). Captive breeding in outdoor aviaries occurs as French regulations do not require a declaration of detention up to 50 individuals (personal communication J.-F. Maillard, June 2020). Wild caught bird trade (as opposed to captive bred) has been suspended in the EU since 2005, when a temporary ban on wild bird imports was installed to prevent the spread of avian influenza (Reino et al., 2017). The ban was made permanent in 2007 and considers all wild caught bird imports regardless of species' conservation status. This ban has been effective in reducing propagule pressure (Cardador et al., 2019). We did not find any records of illegal trade into the EU from non-EU countries. At the moment, there are no documented records of illegally imported red-vented bulbuls in the risk assessment area. It is however possible that releases could happen, for instance by activists or pet owners wanting to free their birds, not being able to take care of them, releasing excess birds after overly successful breeding or because of panic releases (cf. Hulme, 2015). However, we know the red-vented bulbul is exchanged/traded between hobbyists within Europe We did not find information on the number of the red-vented bulbul present in the risk assessment area, which makes it impossible to assess propagule pressure. Neither do we know how many birds are exchanged/traded between hobbyists, so we also have no idea of the market for animals bred in captivity. Our confidence is therefore low.

Qu. 1.4b. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	**low** medium high

Response:

As stated in Qu. 1.3b, we do not know if the red-vented bulbul is imported into the EU illegally, making it very difficult to assess if many birds die during transport. We can assume though that the intention is to bring live animals with the aim to keep them and make them reproduce in captivity. Likewise, in the case of exchange/trade between hobbyists, their intention is to keep the birds alive and well during transport to deliver them so survival is likely. Since we have no official records on this matter, confidence is low.

Qu. 1.5b. How likely is the organism to survive existing management practices during transport

and storage along the pathway?

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low **medium** high

Response:

In the case of trade between hobbyists, this is a legal trade pathway with the intention to keep the birds alive and well during transport to deliver them to the buyer. As stated above, we do not know if the red-vented bulbul is imported into the EU illegally. We also do not know of any existing management practices that could possibly kill the red-vented bulbul during transport and storage along this pathway. According to the IUCN, the red-vented bulbul is not subjected to any international management or trade controls (IUCN, 2019). Because of this, we think it is very likely that the red-vented bulbul will survive existing management practices, with medium confidence.

Qu. 1.6b. How likely is the organism to be introduced into the risk assessment area undetected?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	low **medium** high

Response:

The red-vented bulbul has been introduced without being detected at first in several parts of its invasive range in the Pacific and the Middle East (Watling, 1978; Vander Velde, 2002). However, we could not find evidence on any undetected introductions of the red-vented bulbul into the risk assessment area, so confidence is only medium.

Qu. 1.7b. Estimate the overall likelihood of introduction into the risk assessment area based on this pathway?

RESPONSE	very unlikely unlikely **moderately likely**	**CONFIDENCE**	**low** medium high

	likely very likely		

Response:

This species is already present as a pet in private collections in several (if not all) countries within the risk assessment area. Several hobbyist websites currently have the species on offer, suggesting it is very likely to be introduced repeatedly in the future within the risk assessment area. However, information on introduction from outside the risk assessment area is lacking, therefore our response is moderately likely with low confidence.

End of pathway assessment, repeat Qu. 1.3 to 1.7 as necessary using separate identifier.

Qu. 1.2c. TRANSPORT stowaway: Hitchhikers on ship/boat (excluding ballast water and hull fouling) **Is introduction along this pathway intentional (e.g. the organism is imported for trade) or unintentional (e.g. the organism is a contaminant of imported goods)?**

RESPONSE	intentional **unintentional**	**CONFIDENCE**	low medium **high**

Response:

If the red-vented bulbul were to hitchhike on cargo ships or fishing boats, then this would be unintentional transport.

Qu. 1.3c. How likely is it that large numbers of the organism will be introduced through this pathway from the point(s) of origin over the course of one year? including the following elements: ● discuss how likely the organism is to get onto the pathway in the first place. Also comment on the volume of movement along this pathway. ● an indication of the propagule pressure (e.g. estimated volume or number of individuals / propagules, or frequency of passage through pathway), including the likelihood of reinvasion after eradication ● if relevant, comment on the likelihood of introduction based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in introduction whereas for others high propagule pressure (many thousands of individuals) may not.

RESPONSE	very unlikely	**CONFIDENCE**	**low**

	unlikely **moderately likely** likely very likely		medium high

Response:

Some of the introductions of red-vented bulbul on the Marshall Islands could possibly be stowaways on container ships or fishing boats (Vander Velde, 2002; Brochier et al., 2010). Locations of first sightings in Majuro were all in close proximity to its major commercial port. Here, containers enter from Hawaii and Asia, where there are resident populations of red-vented bulbul. There are also speculations that introductions in Hawaii and New Zealand (Auckland in the 1950s) could have been assisted by barge or boat (Islam & Williams, 2000; Heather & Robertson, 1996).

Red-vented bulbuls are known to nest in some unusual places, including the motor of a ceiling fan and the end of a curtain rod, both within buildings (Islam & Williams, 2000). Hence, the possibility exists that a few birds stowed away among some heavy equipment or in crevices on board of a ship (Vander Velde, 2002). However, there are no confirmed stowaways so the confidence level of our answer is low.

This type of introductory event is considered to be moderately likely, since it possibly already happened outside of the risk assessment area. However, there are no official records of this, so confidence level is low.

Qu. 1.4c. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	**low** medium high

Response:

see Qu. 1.3c.

In the past, some birds were stowaways and survived on a ship from Hawaii to Majuro (Marshall Islands), a journey of around 3700 km (Vander Velde et al., 2002). Birds from the population on the Arabian Peninsula could possibly hitchhike to Europe through this pathway (the distance from Dubai to Cyprus is around 6000 km). There is also a population on Fuerteventura, one of the Canary Islands (Spain) (Nowakowski and Dulisz 2019). The journey from Fuerteventura to Cádiz (Spain) is just over 1100 km, which probably is perfectly manageable for the red-vented bulbul.

When it comes to food supply for survival, if a couple of red-vented bulbuls have been able to survive a journey of 3700 km (Vander Velde, 2002), they probably found food or were fed along the way, indicating this could also be possible for journeys of 6000 km or more.

Qu. 1.5c. How likely is the organism to survive existing management practices during transport and storage along the pathway?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	**low** medium high

Response:

There are no known management practices for these birds on ships, hence it is likely to survive transport and storage along the pathway.

Qu. 1.6c. How likely is the organism to be introduced into the risk assessment area undetected?

RESPONSE	very unlikely **unlikely** moderately likely likely very likely	**CONFIDENCE**	**low** medium high

Response:

It is unlikely stowaway red-vented bulbul on cargo ships or fishing boats would remain undetected during the journey. These birds are noisy, active and curious (Vander Velde, 2002). Nonetheless, even if the birds would be detected, there is no certainty that this sighting would ever be reported by the sailors. Since there are no official records of this happening, the confidence is low.

Qu. 1.7c. Estimate the overall likelihood of introduction into the risk assessment area based on this pathway?

RESPONSE	very unlikely unlikely	**CONFIDENCE**	**low** medium

	moderately likely likely very likely		high

Response:

This has possibly happened in the past in the Pacific Ocean, not in the risk assessment area. There are no official records so the confidence is low.

End of pathway assessment, repeat Qu. 1.3 to 1.7 as necessary using separate identifier.

Qu. 1.8. Estimate the overall likelihood of introduction into the risk assessment area based on all pathways and specify if different in relevant biogeographical regions in current conditions. Provide a thorough assessment of the risk of introduction in relevant biogeographical regions in current conditions: providing insight in to the risk of introduction into the Union.

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low medium **high**

Response:

This species is already present in zoological gardens and private collections in multiple countries within the risk assessment area. We did not find any quantitative data though. Since there is a ban on the introduction of wild birds into the EU, from which only zoological gardens with a license are exempted, it is most likely that the red-vented bulbul will be introduced through the first pathway. Introductions into private collections are less likely, and introductions as stowaways will be the least likely. There are no indications of differences between biogeographical regions.

Qu. 1.9. Estimate the overall likelihood of introduction into the risk assessment area based on all pathways in foreseeable climate change conditions? Thorough assessment of the risk of introduction in relevant biogeographical regions in foreseeable climate change conditions: explaining how foreseeable climate change conditions will influence this risk. With regard to climate change, provide information on ● the applied timeframe (e.g. 2050/2070)

● the applied scenario (e.g. RCP 4.5) ● what aspects of climate change are most likely to affect the likelihood of introduction (e.g. change in trade or user preferences) The thorough assessment does not have to include a full range of simulations on the basis of different climate change scenarios, as long as an assessment of likely introduction within a medium timeframe scenario (e.g. 30-50 years) with a clear explanation of the assumptions is provided. However, if new, original models are executed for this risk assessment, the following RCP pathways shall be applied: RCP 2.6 (likely range of 0.4-1.6°C global warming increase by 2065) and RCP 4.5 (likely range of 0.9-2.0°C global warming increase by 2065). Otherwise, the choice of the assessed scenario has to be explained.

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low medium **high**

Response:

The likelihood of introduction will not change in any climate change scenario since none of the pathways will be affected by any of these scenarios.

2 PROBABILITY OF ENTRY

Important instructions:

- Entry is the release/escape/arrival in the environment, i.e. occurrence in the wild. Entry is not to be confused with spread, the movement of an organism within the risk assessment area.
- The classification of pathways developed by the Convention of Biological Diversity (CBD) should be used. For detailed explanations of the CBD pathway classification scheme consult the IUCN/CEH guidance document[5] and the provided key to pathways[6].
- For organisms which are already present in the risk assessment area, only complete this section for current active or if relevant potential future pathways. This section need not be completed for organisms which have entered in the past and have no current pathway of entry.

Qu. 2.1. List relevant pathways through which the organism could enter into the environment.

For each pathway answer questions 2.2 to 2.7 (copy and paste additional rows at the end of this section as necessary). Please attribute unique identifiers to each question if you consider more than one pathway, e.g. 2.2a, 2.3a, etc. and then 2.2b, 2.3b etc. for the next pathway.

In this context a pathway is the route or mechanism of entry of the species into the environment.

If there are no active pathways or potential future pathways this should be stated explicitly here, and there is no need to answer the questions 2.2-2.8

Pathway name:

a) ESCAPE from confinement: Botanical garden/zoo/aquaria (excluding domestic aquaria)
b) ESCAPE from confinement: Pet/aquarium/terrarium species (including live food for such species)
c) TRANSPORT stowaway: Hitchhikers on ship/boat (excluding ballast water and hull fouling)

Deliberate releases of red-vented bulbul for biocontrol of insect pests have also been documented in the Indo-Pacific (Watling, 1978). As this is not an active pathway in the risk assessment area we do not consider it here. Furthermore, outside the risk assessment area, red-vented bulbul was introduced through other intentional release. For example, the initial introduction in 1903 on the Fiji islands was attributed to Indian immigrants bringing the species for bulbul fighting and releasing them to avoid persecution (Parham, 1955; Watling, 1978; Gill et al., 1995). Since 2016 this practice is however banned (Ratnagar, 2015). Also, in several Asian countries (China, Vietnam, Malaysia, Thailand, Korea, Cambodia, possibly more), people “make merit” by releasing captive animals for religious reasons (McNeely, 2001). Although these prayer releases do occur in Asia (McNeely, 2001; Severinghaus & Chi, 1999), we consider them less relevant for Europe and therefore this pathway is not dealt with here.

[5] https://circabc.europa.eu/sd/a/738e82a8-f0a6-47c6-8f3b-aeddb535b83b/TSSR-2016-010%20CBD%20categories%20on%20pathways%20Final.pdf
[6] https://circabc.europa.eu/sd/a/0aeba7f1-c8c2-45a1-9ba3-bcb91a9f039d/TSSR-2016-010%20CBD%20pathways%20key%20full%20only.pdf

Qu. 2.2a. ESCAPE from confinement: Botanical garden/zoo/aquaria (excluding domestic aquaria) **Is entry into the environment intentional (e.g. the organism is released for a specific purpose) or unintentional (e.g. the organism escapes from confinement)?**

RESPONSE	intentional **unintentional**	**CONFIDENCE**	low medium **high**

Response:

Escape, so entry into the environment is unintentional with high confidence.

Qu. 2.3a. How likely is it that large numbers of the organism will enter into the environment along this pathway from the point(s) of origin over the course of one year? including the following elements: ● discuss how likely the organism is to get onto the pathway in the first place. Also comment on the volume of movement along this pathway. ● an indication of the propagule pressure (e.g. estimated volume or number of individuals / propagules, or frequency of passage through pathway), including the likelihood of reinvasion after eradication ● if relevant, comment on the likelihood of entry into the environment based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in entry whereas for others high propagule pressure (many thousands of individuals) may not).

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	low **medium** high

Response:

The red-vented bulbul is present in several EAZA zoological gardens throughout Europe (see Qu. 1.3a). These are all located in Northern or Central Europe, not in Southern Europe, where we expect more suitable habitat and climate for red-vented bulbul. However, as stated above, EAZA only represents a quarter of all European zoological gardens, so there might be some in zoological gardens in Southern Europe.

There is a record of a zoo escape on Fuerteventura (Canary Islands), outside of the risk assessment area. Here, birds escaped from the zoological garden of La Lajita in 2013 (together with common myna *Acridotheres tristis*), settled and started to breed in the surroundings a few years later (Nowakowski and Dulisz 2019). The myna was eradicated from the surroundings of the zoo, yet the bulbuls were left unattended and spread to the rest of the island (Nowakowski and Dulisz 2019). Considering the potential impact on biodiversity of the Canary Islands ecosystems, including by predation on native and endemic species, there are calls for its eradication (SEO/Birdlife 2017).

Qu. 2.4a. How likely is the organism to enter into the environment within the risk assessment area undetected?

RESPONSE	**very unlikely** unlikely moderately likely likely very likely	**CONFIDENCE**	low medium **high**

Response:

It is very unlikely that the red-vented bulbul would be able to escape from a zoological garden without this being noticed. In the event of an escape, the zoo will most likely take measures to recapture the animal. However, a study by Cassey & Hogg (2015) in Australia stated that, compared with mammals and reptiles, bird escapes were significantly less likely to be retrieved, and more likely to remain undetected.

Qu. 2.5a. How likely is the organism to enter into the environment during the months of the year most appropriate for establishment?

RESPONSE	very unlikely **unlikely** moderately likely likely very likely	**CONFIDENCE**	**low** medium high

Response:

Mean annual temperature is the limiting factor for most of the risk assessment area. If the red-vented bulbul would escape in northern Europe, then it would likely enter a habitat which is too cold in autumn, winter and spring. The bird could possibly survive if it would enter into the environment during summer.

For more information on climate suitability see Qu. A7.

Qu. 2.6a. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host in the environment?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	CONFIDENCE	**low** medium high

Response:

Zoological gardens are often located in urbanized areas, meaning that if the red-vented bulbul would escape, it would easily find an urban garden or park in which to establish. As mentioned in Qu. 2.5a, if the zoological garden is located too northerly in Europe, the climate will be too cold during autumn, winter and spring.

Qu. 2.7a. Estimate the overall likelihood of entry into the environment within the risk assessment area based on this pathway?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	CONFIDENCE	**low** medium high

Response:

If the red-vented bulbul is present in zoological gardens within its predicted suitable habitat, then it is moderately likely that the species would enter into the environment within the risk assessment area. Given that we do not have information on the presence of the red-vented bulbul in zoological gardens within these suitable areas, the confidence level is low.

End of pathway assessment, repeat Qu. 2.2 to 2.7. as necessary using separate identifier.

Qu. 2.2b. ESCAPE from confinement: Pet/aquarium/terrarium species (including live food for such species) Is entry into the environment intentional (e.g. the organism is released for a specific purpose) or unintentional (e.g. the organism escapes from confinement)?

RESPONSE	intentional **unintentional**	**CONFIDENCE**	low medium **high**

Response:

Escape, so entry into the environment is unintentional, with a high confidence level.

Qu. 2.3b. How likely is it that large numbers of the organism will enter into the environment along this pathway from the point(s) of origin over the course of one year? including the following elements: ● discuss how likely the organism is to get onto the pathway in the first place. Also comment on the volume of movement along this pathway. ● an indication of the propagule pressure (e.g. estimated volume or number of individuals / propagules, or frequency of passage through pathway), including the likelihood of reinvasion after eradication ● if relevant, comment on the likelihood of entry into the environment based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in entry whereas for others high propagule pressure (many thousands of individuals) may not).

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	low **medium** high

Response:

The red-vented bulbul is probably kept as a pet in most (if not all) countries within the risk assessment area (see Qu. 1.7b) and the species can easily be found on display for sale online, often under the name "Kala buulbuul" (e.g. www.vogelspeciaalclub.nl). For example, in the Netherlands, the species is kept and bred by members of a bird breeders association specialized in insect and fruit-eating species who adopted a code of best practice for keeping of red-vented bulbul (NBvB, 2014). It is known as a hardy species to keep in aviaries, which is easy to breed on a variety of mealworms and insects when they have young. Several hobby-keeper websites indicate that red-vented bulbul wings should not be clipped, since they exercise by flying, not by climbing. Some websites indicate the species should be kept in a large walk-in aviary, preferably outdoors, implying a higher chance of escape compared to birds kept inside in small cages. Additionally, red-vented bulbuls are often sold and kept in pairs, which implies that there is a high chance of breeding when they would escape. Shieh et al. (2006) reported that Pycnonotidae (with Sturnidae, Timaliidae and Cacatuidae) have significantly higher probabilities of escaping from captivity in Asia, in comparison to other birds families.

Considering the locations where birds were observed in the Netherlands and Belgium (see Qu. A6) and the fact that the species is kept in captivity, it can be assumed escapes have happened here in the past.

Qu. 2.4b. How likely is the organism to enter into the environment within the risk assessment area undetected?

RESPONSE	very unlikely **unlikely** moderately likely likely very likely	**CONFIDENCE**	low medium **high**

Response:

If the red-vented bulbul would escape, it is likely that the keeper will alarm neighbours and maybe even animal rescue centres nearby.

Qu. 2.5b. How likely is the organism to enter into the environment during the months of the year most appropriate for establishment?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	low **medium** high

Response:

The red-vented bulbul is a species of equatorial climate, and will most likely only be able to establish in the Mediterranean biogeographical region within the risk assessment area. For more information on climate suitability see Qu. A7 and the SDM.

If this species would escape from its confinement in the south of Europe, then any moment of the year will probably be appropriate for establishment. The species is known to settle in urban areas, where temperatures are higher and food is more readily available, increasing its chances of establishment (Vander Velde, 2002).

In fact, there have been two successful entry events for the red-vented bulbul in the risk assessment area: in Málaga and in Valencia. In Valencia, there has been establishment following the entry of the species. It is possible that these birds escaped, but this has not been recorded.

Confidence level is medium because of the lack of official reports on the matter within the risk assessment area.

Qu. 2.6b. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host in the environment?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	low **medium** high

Response:

See Qu. 2.6a.

Qu. 2.7b. Estimate the overall likelihood of entry into the environment within the risk assessment area based on this pathway?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	low medium **high**

Response:

This sort of event has happened (and was recorded) multiple times in the past outside the risk assessment area. Moreover, this has happened inside the risk assessment area too, but records of this are scarce and not official. The confidence level of our response is still high because of the records outside of the risk assessment area.

End of pathway assessment, repeat Qu. 2.2 to 2.7. as necessary using separate identifier.

Qu. 2.2c. TRANSPORT stowaway: Hitchhikers on ship/boat (excluding ballast water and hull fouling) **Is entry into the environment intentional (e.g. the organism is released for a specific purpose) or unintentional (e.g. the organism escapes from confinement)?**

RESPONSE	intentional **unintentional**	**CONFIDENCE**	low medium **high**

Response:

Birds that hitchhike on a ship/boat would enter unintentionally.

Qu. 2.3c. How likely is it that large numbers of the organism will enter into the environment along this pathway from the point(s) of origin over the course of one year?

including the following elements:

- discuss how likely the organism is to get onto the pathway in the first place. Also comment on the volume of movement along this pathway.
- an indication of the propagule pressure (e.g. estimated volume or number of individuals / propagules, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if relevant, comment on the likelihood of entry into the environment based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in entry whereas for others high propagule pressure (many thousands of individuals) may not).

RESPONSE	very unlikely **unlikely** moderately likely likely very likely	**CONFIDENCE**	**low** medium high

Response:

This sort of event has allegedly happened before in the Pacific (Vander Velde, 2002). However, the number of birds that would actually be able to enter the environment through this pathway over the course of one year will be very low, therefore we score unlikely. Since we have no official records of this happening, our confidence is low.

For more information, see Qu. 1.3c.

Qu. 2.4c. How likely is the organism to enter into the environment within the risk assessment area undetected?

RESPONSE	**very unlikely**	**CONFIDENCE**	low

	unlikely moderately likely likely very likely		medium **high**

Response:

See response Qu. 1.6b.

Qu. 2.5c. How likely is the organism to enter into the environment during the months of the year most appropriate for establishment?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	low **medium** high

Response:

The red-vented bulbul is a species of equatorial climate, and will most likely only be able to establish in the Mediterranean biogeographical region within the risk assessment area. For more information on climate suitability see Qu. A7 and the SDM (Annex VII).

There are populations of the red-vented bulbul on Fuerteventura (Canary Islands) and on the Arabian Peninsula, which are in fact closest to the areas within the risk assessment area where it is most likely that the red-vented bulbul could establish. For additional information regarding months of the year most appropriate for establishment, see response Qu. 2.5b.

Qu. 2.6c. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host in the environment?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	low **medium** high

Response:

See response to Qu. 2.6a.

Qu. 2.7c. Estimate the overall likelihood of entry into the environment within the risk assessment area based on this pathway?

RESPONSE	very unlikely unlikely **moderately likely** likely very likely	**CONFIDENCE**	**low** medium high

Response:

This sort of event has probably happened in the past (not in the RA area), but has not been recorded very well, hence the low confidence.

End of pathway assessment, repeat Qu. 2.2 to 2.7. as necessary using separate identifier.

Qu. 2.8. Estimate the overall likelihood of entry into the environment within the risk assessment area based on all pathways in current conditions and specify if different in relevant biogeographical regions. Provide a thorough assessment of the risk of entry into the environment in relevant biogeographical regions in current conditions.

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low **medium** high

Response:

Entry has happened in several locations within the risk assessment area (at least in the Netherlands, Belgium, Spain, see Qu. A8). Since the red-vented bulbul is kept as a pet and is on display in zoological gardens, escape and release events are bound to occur in the future. Additionally, it is possible that some individuals or pairs will hitchhike with boats coming from areas with a red-vented bulbul population. Entry could happen in all biogeographical regions within the risk assessment area, but establishment will only be possible in the Mediterranean region. For additional information, see Qu. A7 and the SDM.

Qu. 2.9. Estimate the overall likelihood of entry into the environment within the risk assessment area based on all pathways in foreseeable climate change conditions and specify if different in relevant biogeographical regions. Thorough assessment of the risk of entry in relevant biogeographical regions in foreseeable climate change conditions: explaining how foreseeable climate change conditions will influence this risk, specifically if likelihood of entry is likely to increase or decrease for specific pathways.

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low **medium** high

Response:

Climate change will not alter the possibility of entry into the environment, so we score this question the same as we scored the question under current climate. For additional information, see Qu. A7 and SDM (Annex VII).

3 PROBABILITY OF ESTABLISHMENT

Important instructions: ● For organisms which are already established in parts of the risk assessment area, answer the questions with regard to those areas, where the species is not yet established.

Qu. 3.1. How likely is it that the organism will be able to establish in the risk assessment area based on the history of invasion by this organism elsewhere in the world (including similarity between other abiotic conditions within it and the organism's current distribution)?

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low medium **high**

Response:

The red-vented bulbul is a species of an equatorial climate but is also established in cooler and drier climate regions (including the Mediterranean biogeographical region), both in and outside of the risk assessment area. It has so far primarily established in urban areas, of which there is no shortage within the risk assessment area.

Qu. 3.2. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in the risk assessment area?

RESPONSE	very isolated isolated **moderately widespread** widespread ubiquitous	**CONFIDENCE**	low **medium** high

Response:

The climatic niche of the red-vented bulbul corresponds to an equatorial climate according to the Koppen-Geiger classification (Kottek et al., 2006). In the Mediterranean biogeographical region, suitable habitat for the red-vented bulbul is moderately widespread. Under current climate the area predicted suitable represents only 2% of the entire Mediterranean bioregion but is likely to increase under future climatic conditions (see 7a,b; Annex VII, figure 9). Especially Cyprus, the southern islands of Greece, Southern Andalucia (Spain) and the area around Gibraltar, and a small part of France are at risk. With a non-native range that is still expanding, there is a possibility that the potential climatic niche hence the predicted potential distribution is underestimated.

The red-vented bulbul feeds on a variety of fruits, berries, flowers, buds, insects and small vertebrate prey (Bhatt & Kumar 2001). This broad diet that includes cultivated plants allows the red-vented bulbul to find food easily. Red-vented bulbul builds its nest in trees and bushes at different heights, either on the forks of trees, in the middle or at the top (Vijayan, 1980; Zia et al., 2014). According to several studies, preferred nest height varies from 1 - 4 metres and preferred trees are thorny and very close to each other (Vijayan, 1980; Watling, 1983; Zia et al., 2014). The study done by Zia et al. (2014) in the native range in India found that the percentage of failed nests was highest for treetop nests, with most nests being destroyed due to heavy wind, rain or predators. Such thorny trees are omnipresent in the Mediterranean, not the least on the Greek islands, therefore red-vented bulbul has plenty of suitable breeding habitat available in the Mediterranean biogeographical region.

It is unlikely that the red-vented bulbul would be able to establish in the northern Atlantic, Boreal, Pannonian, Steppe, Black Sea, Alpine or Continental biogeographical regions, due to the cold winter (Annex VII). This is corroborated by reports from a keeper in The Netherlands who says that several young died when kept outside due to the cold weather during the night (http://www.buulbuul.nl/Mijn%20Kala%20buulbuul.html).

Qu. 3.3. If the organism requires another species for critical stages in its life cycle then how likely is the organism to become associated with such species in the risk assessment area?

RESPONSE	**N/A** very unlikely unlikely moderately likely likely very likely	**CONFIDENCE**	low medium **high**

Response:

The red-vented bulbul does not require another species for any critical stage of its life cycle.

Qu. 3.4. How likely is it that establishment will occur despite competition from existing species in the risk assessment area?

RESPONSE	very unlikely unlikely moderately likely likely	**CONFIDENCE**	low **medium** high

	very likely		

Response:

Potentially, the red-vented bulbul could compete for food and space (e.g. for nesting) with other bird species. However, as establishment often occurs in (sub)urban areas with gardens, parks and artificial habitat (see A8, A10), usually depleted in local fauna, very low levels of competition with native species can be expected and it is very likely establishment will occur despite this. In the risk assessment area, competition with highly successful native species such as corvids, gulls and starlings could impact establishment in some cases, but there have been no studies that have assessed this so far hence medium confidence.

It should be noted that the red-whiskered bulbul (*P. jocosus*) established around Valencia shortly after the first observation was made in 2003 in the lower Rio Turia basin area (Santos 2015). The red-whiskered bulbul has been reproducing for more than a decade here and was estimated at 100-150 individuals in 2016 (Santos 2015). Detailed impact studies for Spain are equally lacking for this species. However, as the two species of bulbul are now sympatric, there is the possibility of cumulated impact of an entire invasive bird community. Introduced species may act in concert, facilitating one another's invasion, and increasing the likelihood of successful establishment, spread and impact. Such positive interactions among introduced species are relatively common (e.g. between birds/mammals and plants), but few have been studied in detail (Traveset & Richardson 2014). No information on such mechanisms is available for bulbuls.

The red-vented bulbul is known to be aggressive towards other birds in its preferred forage trees, especially during the breeding season (Sherman & Fall, 2010; Blanvillain et al., 2003; Gorman 1972). Competition with other (native) bird species is in fact one of the three serious impact categories associated with red-vented bulbul, so it is unlikely that competition will be limiting for this bird (Thibault et al., 2018d). For example, in Tahiti, red-vented bulbuls compete with the Tahiti monarch (*Pomarea nigra*), an endemic and critically endangered passerine (Blanvillain et al., 2003). Another study, done by Thibault et al. (2018d) in New-Caledonia found that nine out of ten native bird species monitored in man-modified habitats were less abundant when the red-vented bulbul was present. The impact of the red-vented bulbul appears to be restricted to niche contraction of the native species (Thibault et al., 2018d).

A study in New Caledonia (Thibault et al., 2018d) states that there are no indications for interspecific competition with other invasive species present on the island, such as common myna (*Acridotheres tristis*) and red-whiskered bulbul. It is possible that these species show some sort of niche segregation in their invaded range, as shown for red-vented bulbul and common myna in French Polynesia by Bates et al. (2014).

Qu. 3.5. How likely is it that establishment will occur despite predators, parasites or pathogens already present in the risk assessment area?

RESPONSE	N/A	**CONFIDENCE**	low

	very unlikely unlikely moderately likely **likely** very likely		medium **high**

Response:

Predators

The red-vented bulbul is not particularly vulnerable to predation. In its native range, a study carried out by Zia et al. (2017) found that predation rate on red-vented bulbul was only 6% in eggs and 9% in nestlings. Predators in the study area included bird species such as crested eagle (*Morphnus guianensis*) and barn owl (*Tyto alba*), and rodents such as the black rat (*Rattus rattus*). Breeding success in the study was 82% and 86% for eggs and fledglings, respectively. The red-vented bulbul has specific behavioural adaptations to avoid predatory impact during nesting, notably through broken-wing display, that one or both parents would perform when a predator is seen near the nest (Kumar 2004, 2010).

Parasites

In its native range, the red-vented bulbul is known to host the internal parasite *Isospora* spp. known to cause isosporiasis in passerine birds (Boughton et al., 1938), lice species such as *Menacanthus eurysternus* (Price 1975), *Bruelia guldum*, *Sturnidoecus guldum* (Ansari 1957), the mite *Pteroherpus pycnonoti* (Constantinescu et al., unpublished) as well as disease carrying ticks (Islam & Williams, 2000; Vander Velde & Vander Velde 2013; Thibault et al., 2018c). Vander Velde and Vander Velde (2013) considered the constant influx of red-vented bulbuls on Micronesia a potential risk for the spread of tick-borne diseases.

Pathogens

In 1996, Jarvi et al. (2003) detected no avian malaria (*Plasmodium spp.*) in blood smears, and Atkinson et al. (2006) found no evidence of *Plasmodium*, *Trypanosoma*, *Atoxoplasma* or microfilaria. Red-vented bulbuls in Tahiti, however, have been found to carry the zoonotic disease *Chlamydia sp.* (Blanvillain et al., 2013). Grewal (1964) experimentally infected red-vented bulbuls with *Plasmodium praecox* (= *relictum*), the most widespread malaria parasite of birds. The birds developed typical infections about a week after inoculation and survived without apparent. The species may therefore be a carrier in nature (Grewal 1964).

Qu. 3.6. How likely is the organism to establish despite existing management practices in the risk assessment area?

RESPONSE	very unlikely unlikely moderately likely likely	**CONFIDENCE**	low medium **high**

	very likely		

Response:

There are no known existing management practices against this species in the risk assessment area.

Qu. 3.7. How likely are existing management practices in the risk assessment area to facilitate establishment?

RESPONSE	**very unlikely** unlikely moderately likely likely very likely	**CONFIDENCE**	low medium **high**

Response:

There are no known existing management practices against this species in the risk assessment area.

Qu. 3.8. How likely is it that biological properties of the organism would allow it to survive eradication campaigns in the risk assessment area?

RESPONSE	very unlikely **unlikely** moderately likely likely very likely	**CONFIDENCE**	low **medium** high

Response:

As stated before, the red-vented bulbul is a loud species and it is thus unlikely to stay undetected. It is in fact this biological property that will make it more susceptible to eradication campaigns.

The most suitable habitat for the red-vented bulbul are Cyprus and the Greek islands. Invasive alien species control tends to be more achievable on islands than on the continent (Myers et al., 2000; McGeoch et al., 2016).

For more information, see the Annex with control measures.

Qu. 3.9. How likely are the biological characteristics of the organism to facilitate its establishment in the risk assessment area?
including the following elements: ● a list and description of the reproduction mechanisms of the species in relation to the environmental conditions in the Union ● an indication of the propagule pressure of the species (e.g. number of gametes, seeds, eggs or propagules, number of reproductive cycles per year) of each of those reproduction mechanisms in relation to the environmental conditions in the Union. If relevant, comment on the likelihood of establishment based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in establishment whereas for others high propagule pressure (many thousands of individuals) may not.

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low medium **high**

Response:

The red-vented bulbul lives in anthropogenic landscapes in all of its alien range in the Pacific, Houston, Fuerteventura, Málaga and Valencia, so it can be assumed that the highly fragmented and anthropogenic landscape in southern Europe will not hamper its establishment.

If a pair escapes or is released from confinement, a population could establish from just this pair given that genetic diversity is sufficiently high. This is allegedly what happened in the Republic of the Marshall Islands, when a pair may have hitchhiked on a ship and established a population (Vander Velde, 2002).

The red-vented bulbul often has two to three broods per year, that consist of two to five eggs (Long, 1981; Vander Velde, 2002), with an incubation period of about 14 days (Berger, 1972). Consequently, population size is likely to increase fast, leading to establishment.

Qu. 3.10. How likely is the adaptability of the organism to facilitate its establishment?

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low medium **high**

Response:

The red-vented bulbul is a species that thrives in urban and suburban gardens and parks, indicating that it is an adaptable species (Brooks, 2013; Thibault, 2018a). Thibault (2018a) showed that densities in suburban areas vary along an urbanization gradient, but can go up to 120 individuals/km^2. In their native range, bulbuls are found from 0 to 2,000m, along forest edges, as well as in gardens and cultivated areas. These habitats have plenty of exotic plant species available to red-vented bulbul, usually not or little consumed by local wildlife, a resource that can easily be exploited by these adaptable birds and offering some advantage over native passerines. Virtually all of the bulbuls in Houston are found in residential gardens at sea level, with the only other cases being fragments of secondary habitat in edge situations.

Qu. 3.11. How likely is it that the organism could establish despite low genetic diversity in the founder population?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	low medium **high**

Response:

No genetic diversity studies have been done on the red-vented bulbul, but several studies on singular breeding species (i.e., species that breed in pairs on a defended territory) show that these do not avoid random mating (Van Tienderen & van Noordwijk, 1988; Keller & Arcese, 1998; Hansson et al., 2007). However, Kruuk et al. (2002) noticed severe inbreeding depression in collared flycatchers, indicating species-specific differences in inbreeding tolerance.

Even with a small founder population, the red-vented bulbul has established in several parts of the world where it is thriving (also see Qu. A5).

Qu. 3.12. If the organism does not establish, then how likely is it that casual populations will continue to occur?

Consider, for example, a species which cannot reproduce in the risk assessment area, because of unsuitable climatic conditions or host plants, but is present because of recurring introduction, entry and release events. This may also apply for long-living organisms.

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low medium **high**

Response:

Since the red-vented bulbul is a popular pet bird and is present in zoological gardens, there is a continuous risk of release and escape in the future. Actual recurring introduction, entry and release events without establishment will happen in areas with unsuitable climatic conditions, e.g. in many colder parts of Europe, where it is too cold for the red-vented bulbul to reproduce successfully.

Qu. 3.13. Estimate the overall likelihood of establishment in the risk assessment area based on the similarity between climatic conditions within it and the organism's current distribution under current climatic conditions. In addition, details of the likelihood of establishment in relevant biogeographical regions under current climatic conditions should be provided.

Thorough assessment of the risk of establishment in relevant biogeographical regions in current conditions: providing insight in the risk of establishment in (new areas in) the Union.

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low **medium** high

Response:

As stated in Qu. A7 and the SDM (Annex VII), establishment is most likely in the Mediterranean biogeographical region but only a small proportion of the area is predicted suitable. Indeed, establishment has already happened in Valencia (Spain). The ensemble model (Annex VII) suggested that the suitable distribution area for red-vented bulbul was most strongly determined by Annual mean temperature (Bio1), accounting for 43.5% of variation explained, followed by Mean temperature of the warmest quarter (Bio10) (24.7%). Annual mean temperature (Bio1) was also the most strongly limiting factors for establishment of red-vented bulbul in most of Europe and the Mediterranean region in current climatic conditions. In some Mediterranean areas (southern Iberia, Balearic islands, Sicily and Sardinia, Greece and Aegean islands, Cyprus), Precipitation of the wettest month (Bio13) was the most limiting factor. Other climatic variables such as Precipitation of the wettest month (Bio13) (8.8%), Minimum temperature of the coldest month (Bio6) (8.3%), Annual precipitation (Bio12) (5.9%) and Precipitation of the driest month (Bio14) (2.3%) explained much less of the variation in the species distribution model. The considered Non-climatic factors Human influence index (HII) (5.6%) and Global tree cover (Tree) (0.9%) explained only little of the observed variation. For information about important non-climatic variables, see Qu. 3.14.

Qu. 3.14 Estimate the overall likelihood of establishment in the risk assessment area under foreseeable climate change conditions. In addition, details of the likelihood of establishment in relevant biogeographical regions under foreseeable climate change conditions should be

provided. Thorough assessment of the risk of establishment in relevant biogeographical regions in foreseeable climate change conditions: explaining how foreseeable climate change conditions will influence this risk. With regard to climate change, provide information on ● the applied timeframe (e.g. 2050/2070) ● the applied scenario (e.g. RCP 4.5) ● what aspects of climate change are most likely to affect the likelihood of establishment (e.g. increase in average winter temperature, increase in drought periods) The thorough assessment does not have to include a full range of simulations on the basis of different climate change scenarios, as long as an assessment of likely establishment within a medium timeframe scenario (e.g. 30-50 years) with a clear explanation of the assumptions is provided. However, if new, original models are executed for this risk assessment, the following RCP pathways shall be applied: RCP 2.6 (likely range of 0.4-1.6°C global warming increase by 2065) and RCP 4.5 (likely range of 0.9-2.0°C global warming increase by 2065). Otherwise, the choice of the assessed scenario has to be explained.

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low **medium** high

Response:

As stated in Qu. A7 and the SDM (Annex VII), establishment is estimated to be possible in the Mediterranean biogeographical regions under both RCP 2.6 and RCP 4.5. The Mediterranean will remain the most vulnerable region under climate change. The proportion of the area suitable for establishment in the Mediterranean biogeographical region is predicted to double under RCP 2.6 and to triple under RCP 4.5 by 2070. Therefore, we scored very likely.

4 PROBABILITY OF SPREAD

Important instructions: ● Spread is defined as the expansion of the geographical distribution of an alien species within the risk assessment area. ● Repeated releases at separate locations do not represent continuous spread and should be considered in the probability of entry section. In other words, intentional anthropogenic "spread" via release or escape ("jump-dispersal"), should be dealt within the entry section. However, as repeated releases contribute to the spread of the target organism in the risk assessment area, the relevant pathway(s) should be briefly discussed here too, with an explicit reference to the entry section for additional details.

Qu. 4.1. How important is the expected spread of this organism within the risk assessment area by natural means? (List and comment on each of the mechanisms for natural spread.)
including the following elements: ● a list and description of the natural spread mechanisms of the species in relation to the environmental conditions in the risk assessment area. ● an indication of the rate of each of those spread mechanisms in relation to the environmental conditions in the Union. The description of spread patterns should include elements of the species life history and behavioural traits able to explain its ability to spread, including: reproduction or growth strategy, dispersal capacity, longevity, dietary requirements, environmental and climatic requirements, specialist or generalist characteristics.

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	low **medium** high

Response:

For information on spread outside of the risk assessment area, see Qu. A5. For information on spread inside of the risk assessment area, see Qu. A8(b). There is a discrepancy between spread rate inside and outside of the risk assessment area, the rate being higher outside than inside. The rate of spread will be dependent on propagule pressure and the size of the population that has established.

Life history traits important for spread: the breeding season in the red-vented bulbul starts in February and lasts till September (Zia et al., 2014). Nest construction period is only 2 - 5 days, which is notably faster than other Pycnonotids like yellow-throated bulbul and grey-headed bulbul for which nest building takes 3 - 8 days (Balakrishnan, 2010). According to a study performed by Zia et al. (2014), preferred nest-building vegetation of the red-vented bulbul was beri (*Zizyphus nummularia*) (31%) followed by guava (*Psidium guajava*) (22%), sheesham (*Dalbergia sissoo*) (18%), snatha (*Dodonea viscosa*) (16%) and date palm (*Phoenix dactylifera*) (13%). Clutch size in general in Pycnonotids is two and rarely three (Ali & Ripley, 1987). Clutch size of the red-vented bulbul varies from 1 - 4, and there are indications that this varies between regions, as studies from different regions of the species' range have partially different results (Zia et al., 2017; Prajapati et al., 2011; Rao et al., 2013).

The study done by Zia et al. (2014) also recorded the predators of the red-vented bulbul nests. Mostly, rodents and raptors were responsible for failed nests, e.g. brown rat (*Rattus rattus*), barn owl (*Tyto alba*) and crested eagle (*Morphnus guianensis*). Another interesting found in the study was that nests made in beri plants were more likely to fail which could be connected to their location near residential areas, where human disturbance and urban pollution could have an effect on red-vented bulbul reproductive success.

Qu. 4.2. How important is the expected spread of this organism within the risk assessment area by human assistance? (List and comment on each of the mechanisms for human-assisted spread and provide a description of the associated commodities.) including the following elements: ● a list and description of the anthropogenic spread mechanisms of the species in relation to the environmental conditions in the Union. ● an indication of the rate of each of those spread mechanisms in relation to the environmental conditions in the Union.

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	**low** medium high

Response:

The red-vented bulbul is known to nest in unusual sites (see Qu. 1.3b), and it could therefore spread by human assistance on cargo ships or fishing boats within the risk assessment area. It appears that this species preferentially spreads through urban corridors, possibly facilitating its spread in most European countries.

Qu. 4.2a. List and describe relevant pathways of spread. Where possible give detail about the specific origins and end points of the pathways. For each pathway answer questions 4.3 to 4.9 (copy and paste additional rows at the end of this section as necessary). Please attribute unique identifiers to each question if you consider more than one pathway, e.g. 4.3a, 4.4a, etc. and then 4.3b, 4.4b etc. for the next pathway. including the following elements: ● a list and description of pathways with an indication of their importance and associated risks (e.g. the likelihood of spread in the Union, based on these pathways; likelihood of survival, or reproduction, or increase during transport and storage; ability and likelihood of transfer from the pathway to a suitable habitat or host). Where possible details about the specific origins and end points of the pathways shall be included.

- an indication of the propagule pressure (e.g. estimated volume or number of specimens, or frequency of passage through pathway), including the likelihood of reinvasion after eradication.
- All relevant pathways should be considered. The classification of pathways developed by the Convention of Biological Diversity shall be used.

Pathway name:

TRANSPORT (stowaway) - Hitchhikers on ship/boat (excluding ballast water and hull fouling)

Qu. 4.3a. Is spread along this pathway intentional or unintentional (e.g. the organism is a contaminant of translocated goods within the risk assessment area)?

RESPONSE	intentional **unintentional**	**CONFIDENCE**	low medium **high**

Response:

Unintentional.

Qu. 4.4a. How likely is it that a number of individuals sufficient to originate a viable population will spread along this pathway from the point(s) of origin over the course of one year?

including the following elements:

- an indication of the propagule pressure (e.g. estimated volume or number of specimens, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if appropriate, indicate the rate of spread along this pathway
- if appropriate, include an explanation of the relevance of the number of individuals for spread with regard to the biology of species (e.g. some species may not necessarily rely on large numbers of individuals).

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	**low** medium high

Response:

Introduction, establishment and spread of the red-vented bulbul has allegedly happened through this pathway in the Pacific, suggesting that this could happen in the risk assessment area as well (Vander Velde et al., 2002). The red-vented bulbul was first sighted on the Marshall Islands in 2000 near the major commercial dock of Majuro and in 2002, there were already several breeding populations (Vander Velde, 2002).

The Mediterranean region and the Greek islands in particular are vulnerable given the large amount of islands and boat (commercial and leisure) traffic between them.

Also see response to Qu 1.3c and 1.4c.

Qu. 4.5a. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	**CONFIDENCE**	**low** medium high

Response:

This sort of event has allegedly already happened in the Pacific (Vander Velde et al., 2002), but evidence is scarce, hence the low level of confidence. See Qu. 1.3c & 1.4c.

Qu. 4.6a. How likely is the organism to survive existing management practices during spread?

RESPONSE	very unlikely unlikely moderately likely likely **very likely**	**CONFIDENCE**	low medium **high**

Response:

There are no known existing management practices on ships that would target the red-vented bulbul.

Qu. 4.7a. How likely is the organism to spread in the risk assessment area undetected?

RESPONSE	**very unlikely** unlikely moderately likely likely very likely	CONFIDENCE	low medium **high**

Response:

Also see Qu. 2.4a.

Qu. 4.8a. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host during spread? (including, where possible, details about the specific origins and end points of the pathway)

RESPONSE	very unlikely unlikely moderately likely **likely** very likely	CONFIDENCE	**low** medium high

Response:

If the organism would spread through the Mediterranean by boat transport, it would enter new areas through harbours, which are often close to urbanisation. This would enhance its chances of spread, since the species is known to settle in urban areas (Vander Velde, 2002), where temperatures are higher and food is more readily available, increasing its chances of establishment.

Qu. 4.9a. Estimate the overall potential rate of spread within the Union based on this pathway? (please provide quantitative data where possible).

RESPONSE	very slowly **slowly** moderately rapidly very rapidly	CONFIDENCE	**low** medium high

Response:

Spread through this pathway has possibly happened in the Pacific, and could happen in the risk assessment area, especially in the Mediterranean region. However, there are no official records of this so confidence is low.

End of pathway assessment, repeat Qu. 4.3 to 4.9. as necessary using separate identifiers.

Qu. 4.10. Within the risk assessment area, how difficult would it be to contain the organism in relation to these pathways of spread?

RESPONSE	very easy easy **with some difficulty** difficult very difficult	**CONFIDENCE**	**low** medium high

Response:

The species is easily recognisable and will probably be detected when present on a ship. However, even if conspicuous, the species does have a track-record as a stowaway (Vander Velde et al., 2002). Should the red-vented bulbul get more firmly established in the risk assessment area, it would take considerable effort to implement biosecurity procedures preventing stowaways, for example through controls on shipping routes between Mediterranean islands. We found no information on standard measures that sailors take to prevent the birds from escaping the ship. We did find some recommendations from the Australian government for sailors that encounter a stowaway animal on a ship: closing container or vessel doors, creating barriers; isolating the affected cargo in an area away from other goods; using blankets to restrict animal movement; taking photos of the animal or try to catch it. As these sets of measures are complex, we assume this would be implemented with some difficulty at least.

Qu. 4.11. Estimate the overall potential rate of spread in relevant biogeographical regions under current conditions for this organism in the risk assessment area (indicate any key issues and provide quantitative data where possible). Thorough assessment of the risk of spread in relevant biogeographical regions in current conditions, providing insight in the risk of spread into (new areas in) the Union.

RESPONSE	very slowly slowly **moderately** rapidly very rapidly	**CONFIDENCE**	low **medium** high

Response:

Groups and families of the red-vented bulbul can be seen in Valencia, but their range is small (Carlos Gutiérrez-Expósito, personal communication 2018), suggesting that (mainland) spread is slow. For additional information, see Qu. A8. The relatively slow spread could however be context dependent (e.g. environmental conditions, lack of suitable dispersal corridors, food availability) and therefore it is difficult to generalize the Valencia case to the whole risk assessment area. Invasion histories elsewhere in the world illustrate the species is certainly able to spread in insular contexts where highly attractive habitat is linked by boats.

Qu. 4.12. Estimate the overall potential rate of spread in relevant biogeographical regions in foreseeable climate change conditions (provide quantitative data where possible). Thorough assessment of the risk of spread in relevant biogeographical regions in foreseeable climate change conditions: explaining how foreseeable climate change conditions will influence this risk, specifically if rates of spread are likely slowed down or accelerated.

RESPONSE	very slowly slowly **moderately** rapidly very rapidly	**CONFIDENCE**	low **medium** high

Response:

The species is classified as a rather sedentary species, showing possible movements depending on environmental conditions (del Hoyo et al., 2005). The invasion on Fuerteventura, where the species invaded the entire island in a few decades and has shown important range expansion in the period 2013–2018 (Nowakowski and Dulisz 2019) indeed shows spread could be very context-dependent and the species is certainly able to spread moderately rapidly or rapidly in insular contexts.

5 MAGNITUDE OF IMPACT

Important instructions:
● Questions 5.1-5.5 relate to biodiversity and ecosystem impacts, 5.6-5.8 to impacts on ecosystem services, 5.9-5.13 to economic impact, 5.14-5.15 to social and human health impact, and 5.16-5.18 to other impacts. These impacts can be interlinked, for example a disease may cause impacts on biodiversity and/or ecosystem functioning that leads to impacts on ecosystem services and finally economic impacts. In such cases the assessor should try to note the different impacts where most appropriate, cross-referencing between questions when needed. ● Each set of questions starts with the impact elsewhere in the world, then considers impacts in the risk assessment area (=EU excluding outermost regions, and the United Kingdom) separating known impacts to date (i.e. past and current impacts) from potential future impacts (including foreseeable climate change). ● Only negative impacts are considered in this section (socio-economic benefits are considered in Qu. A.7)

Biodiversity and ecosystem impacts

Qu. 5.1. How important is the impact of the organism on biodiversity at all levels of organisation caused by the organism in its non-native range excluding the risk assessment area?
including the following elements: ● Biodiversity means the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems ● impacted chemical, physical or structural characteristics and functioning of ecosystems

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	low medium **high**

Comment:

Impacts on biodiversity were comprehensively reviewed by Thibault et al. (2018a) and include impact on native fauna through competition and community changes due to dispersal of invasive alien plant seeds. The authors note the lack of quantified impact studies and based on this, challenge the inclusion of red-vented bulbul on the list of the world’s worst invasive species (Lowe et al., 2004). Evans et al. (2016), in their EICAT assessment of 415 bird species, scored impact of the red-vented bulbul as Moderate (MO) (i.e. *it causes declines in the population size of native species, but no changes to the structure of communities or to the abiotic or biotic composition of ecosystems*) with high confidence and list competition and interaction with other alien species (spreading the seeds of alien plants and thereby mediating alien plant invasions) as the impact mechanisms causing the most severe impacts. Martin-Albarracin et al. (2015) and Baker et al. (2014), in a global analysis of alien bird impact, note competition and interactions with other non-native species as impact mechanisms. According to their scoring system used (an adapted scheme based on Kumschick and Nentwig (2010) and Blackburn et al. (2014), where 0 indicates no impact detected and 5 massive impact), the red-vented bulbul scores 2 on competition (i.e. *competition with several native species by exploitation competition, without large impact on affected species or decline of their populations*) and 4 on interactions with other species (i.e. *dispersal of seeds of non-native plants facilitates local or population extinction of at least one native species, and produces changes in community composition that are reversible but would not have occurred in the absence of the species*).

Impact mechanisms:

1: Frugivory (spreading the fruit/seeds of alien plants)

Thibault et al. (2018c) compiled lists of 110 plant species consumed and 33 plant species dispersed by red-vented bulbul. In the literature there are at least 56 mentions of problematic seed dispersal by the species from eight locations (six countries) (Thibault et al., 2018c). Red-vented bulbul is considered a major vector of some notoriously problematic invasive alien plant species on islands, such as the invasive tree miconia (*Miconia calvescens*) and lantana (*Lantana camara*) in French Polynesia (Meyer, 1996; Spotswood et al., 2012; 2013), lantana (*Lantana camara*), prickly solanum (*Solanum torvum*) and cape gooseberry (*Physalis angulata*) on Fiji (Fox, 2011), ivy gourd (*Coccinia grandis*) on Oahu and Brazilian peppertree (*Schinus terebinthifolius*) in New Caledonia (Spotswood et al., 2012; Thouzeau-Fonseca, 2013). Watling (1978) described the early invasion in the Indo-Pacific region and noted that the distribution of the red-vented bulbul on islands could be determined by the presence of three weed species the species used as principal food: spiked pepper (*Piper aduncum*), turkey berry (*Solanum torvum*) and Cape gooseberry (*Physalis peruviana*). All of these introduced, weedy species subsequently spread on islands with bulbuls present (Watling 1978). 2: Competition

Blanvillain et al. (2003) provide evidence of competition with Tahiti monarch (*Pomarea nigra*), a forest bird endemic to Tahiti (French Polynesia). They noted aggressive interactions (e.g. alarm calls and chasing) between flycatchers and red-vented bulbuls during and outside reproductive activity and suggest this interspecific competition for nest sites and territories might be in part responsible for low breeding success of the Tahiti flycatchers. In contrast, interactions with common myna (*Acridotheres tristis*) were more common when the birds had chicks and eggs in the nest and therefore mynas had a more important direct impact as nest predators of the monarchs (Blanvillain et al., 2003). Competition between red-vented bulbul and other remaining native birds in Fiji forests was also suspected based on reported interspecific aggressive interactions towards at least four native species mostly during the bulbul's breeding season. This caused habitat shifts in native birds (Watling 1978, 1983). Thibault et al. (2018d) provide evidence for competition in man-modified habitats in New Caledonia showing a negative relationship between red-vented bulbul and the abundance of nine native (including endemic) species with which its distribution range overlaps, hence red-vented bulbul is believed to drive reassembly of native species toward sub-optimal locations along an urban-rural gradient, by its aggressive behaviour enabling it to out-compete native species and dominate access to food (Thibault et al., 2018d). Interestingly, the abundance of other introduced alien species (*Acridotheres tristis, Passer domesticus, Spilopelia chinensis*) was not affected.

3: Hybridisation

Also, some studies report the presence of hybrids due to cross-breeding with native related bulbuls, such as white-cheeked bulbul (*Pycnonotus leucogenys*), white-eared bulbul (*P. leucotis*) and yellow-vented bulbul (*P. xanthopygos*) in the Middle East (Khamis, 2010; Thibault et al., 2018ab). In Bahrain, two local bird ringers (Brendan Kavanagh and Abdulla Al-Khaabi) recorded a cross-breeding incident between the red-vented bulbul and the white-cheeked bulbul (*P. leucogenys*), where they observed hybrid chicks in a nest. A culturally important species, the local population of the white-cheeked bulbul is under the continuous threat of habitat degradation and poaching. Hence, cross-breeding, which leads to sterile offspring, forms an additional threat to this already vulnerable species and should be considered seriously (Khamis, 2010). Hybridisation of red-vented bulbul with common bulbul (*P. barbatus*), which is one of the commonest birds in Africa that only recently started breeding in southern Spain around Tarifa, has not been reported. Common bulbul is however known to hybridize with four other species, from Africa (*P. capensis*, *P. nigricans*, *P. tricolor*) and the Middle East (*P. xanthopygos*) (https://avibase.bsc-eoc.org/).

4: Predation

Other impacts include predation on invertebrates such as Hemiptera, Coleoptera, Odonata, Lepidoptera (Fox, 2011)), Hymenoptera and Diptera, as well as small reptiles including geckos and skinks (Brooks et al., 2013; Thibault et al., 2019). On Hawaii, predation by red-vented bulbul and red-whiskered bulbul on larvae and adults of the iconic monarch butterfly *Danaus plexippus* (Lepidoptera: Nymphalidae) led to changes in the proportions of colour morphs in the population (Stimson and Kasuya 2000). Clearly, bulbuls are not deterred by the cardiac glycosides in the monarchs' tissues and can exert heavy predation on larvae feeding on their host plant milkweed (Stimson and Berman 1990). However, we could find no evidence of population level impacts on these species.

Based on and in line with these assessments of alien birds and with species-specific studies we consider the current impact of red-vented bulbul outside the risk assessment area as moderate. Although it is noted that its harmful effects on agricultural systems and native fauna could be highly context-dependent (Thibault, 2018a), there is good evidence of the species altering ecosystems through the spread of seeds of other alien and invasive plant species, and for competition with other bird species, but there is no evidence of red-vented bulbul causing extinctions. This is in line with Thibault et al. (2018d) who suggest that red-vented bulbul causes niche contractions rather than mortality in native species, especially in human-modified landscapes where native birds are already under pressure. No documented cases of recovery of native species after *Pycnonotus* eradication was found, but presumably, as native species are rather displaced and pushed out of optimal habitat, this process is also reversible. Hence a moderate impact score but with high confidence as there are a good number of reliable impact studies on red-vented bulbul from several populations in its invasive range.

Qu. 5.2. How important is the current known impact of the organism on biodiversity at all levels of organisation (e.g. decline in native species, changes in native species communities, hybridisation) in the risk assessment area (include any past impact in your response)?

Discuss impacts that are currently occurring or are likely occurring or have occurred in the past in the risk assessment area. Where there is no direct evidence of impact in the risk assessment area (for example no studies have been conducted), evidence from outside of the risk assessment area can be used to infer impacts within the risk assessment area.

RESPONSE	**minimal** minor moderate major massive	CONFIDENCE	**low** medium high

Comment:

No direct evidence is available on impact of red-vented bulbul in the risk assessment area. Since the only established population in Spain is presumably still small, impact can be assumed to be minimal but with low confidence due to the lack of impact studies in the RA area.

Qu. 5.3. How important is the potential future impact of the organism on biodiversity at all levels of organisation likely to be in the risk assessment area?
See comment above. The potential future impact shall be assessed only for the risk assessment area.

RESPONSE	minimal minor **moderate** major massive	CONFIDENCE	**low** medium high

Comment:

The species could have impacts on native biodiversity at places where it becomes more widely established and numerous, such as in peri-urban habitats, but also more natural vegetation types such as maquis, open dry scrubland, and forest edge habitat. Here, following the same categorisation of impact mechanisms as in the alien range (see Qu. 5.1), we identified a number of potentially sensitive receptors (species, habitats, protected areas) within the risk assessment area which could be impacted upon, considering the areas where the species is already established or areas predicted suitable for establishment (Iberia, Mediterranean, Mediterranean islands).

1: Frugivory (spreading the fruit/seeds of alien plants)

Because of its frugivorous diet, the red-vented bulbul is a possible disperser of invasive alien plant seeds (see Q5.1), and could thus facilitate invasions of invasive plants (Traveset, 2006; Traveset and Richardson 2014; MacFarlane et al., 2016). It is well known that island ecosystems are especially sensitive to the impacts of invasive alien species and because of high levels of endemicity (e.g. Tershy et al., 2015; Bellard et al., 2016). The Mediterranean basin is particularly vulnerable to invasive alien plant invasions because its climatic conditions potentially allow the establishment of sub-tropical and tropical species (Lambdon et al., 2008; Brunel et al., 2010; Brundu 2015). Mediterranean islands are especially vulnerable (Lloret et al., 2005; Vila et al., 2006, 2008; Hulme et al., 2008). A number of established and emerging invasive alien plants for Mediterranean countries produce fleshy fruits and could therefore potentially be spread by birds such as the red-vented bulbul in the risk assessment area (cf. Gosper et al., 2005; Spotswood et al., 2012, 2013). American pokeweed (*Phytolacca americana*) and Indian pokeweed (*P. acinosa*) produce fleshy purple berries that are spread by birds (McDonnell et al., 1984). Other examples of (potentially) invasive alien plants that might be spread by red-vented bulbuls in the risk assessment area include Brazilian peppertree (*Schinus terebinthifolius*), a commonly planted ornamental in the Mediterranean which is reported to be spread by the species (Thibault et al., 2018c), silver-leaved nightshade (*Solanum elaeagnifolium*), a common agricultural weed (Brunel et al., 2010), sticky nightshade (*S. sisymbriifolium*), a weed of pastures and irrigated crops, roseleaf bramble (*Rubus rosifolius*), Chinese privet (*Ligustrum sinense*) and garden privet (*L. ovalifolium*) (Tanner 2017). Some of these species typically occur in human-modified areas such as parks, gardens and ruderal terrains. By comparison, also red-whiskered bulbuls (*P. jocosus*), a species with comparable ecology, are notorious for spreading invasive weeds including *Lantana* spp., *Rubus* spp., *Phytolacca* spp., *Chrysanthemoides* spp. and *Ligustrum* spp. in Mediterranean parts of Australia and this is considered their biggest impact on ecosystems (Mo 2015). In Spain, red-whiskered bulbuls have been reported feeding on seeds and fruits of native as well as non-native plant species e.g. kurrajong (*Brachychiton populneus*), fig (*Ficus carica*), strawberry tree (*Arbutus unedo*), loquat (*Eriobotrya japonica*), privet (*Ligustrum vulgare*), chinaberry tree (*Melia azedarach*), pomegranate (*Punica granatum*), Peruvian pepper (*Schinus molle*), date palm (*Phoenix dactylifera*), oleander (*Nerium oleander*) flowers, feijoa (*Acca sellowiana*) and yucca (*Yucca* sp.). On Mauritius, red-whiskered bulbuls also have similar species in their diets e.g. *Ligustrum robustum*, *Rubus rosifolius*, *Rubus alceifolius* (Linnebjerg et al., 2010). Spread of typical garden ornamentals by red-vented bulbul could be an issue in the Mediterranean considering the habitat preference of the species for gardens and man-made habitat, for example *Trachycarpus fortunei*, *Mahonia aquifolium*, non-native *Ribes* sp., *Parthenocissus* sp., *Cotoneaster* sp., *Rosa* sp., *Elaeagnus* sp., *Ziziphus jujuba*, *Morus* sp., *Pittosporum* sp., *Myoporum* sp., *Mirabilis jalapa*, *Opuntia* sp., *Lycium* sp., *Lonicera* sp., *Aralia* sp. and *Hedera* sp. With regards to IAS of Union concern (Union list as it stands in 2019), *Persicaria perfoliata* is the only species that produces berry-like fruits (personal communication G. Brundu, 23/10/2019).

2: Competition

Impact on native bird species will mostly occur through competition for food or space including harassment of native birds by (groups of) red-vented bulbul, being chased away or on the nest through territorial interactions (see Qu. 5.1). However, as the species mostly occurs in urban, human influenced landscapes, most of the passerine species it would compete with are relatively common (e.g. blackcap *Sylvia atricapilla*, Sardinian warbler *S. melanocephala*, common blackbird *Turdus merula*, house sparrow *Passer domesticus*) and the presence of the bulbul is expected to lead mostly to niche contraction rather than declines or extinctions (cf. the reported impact of the species on Tahiti monarch, Blanvillain et al., 2003) hence a score of moderate. Other potentially impacted species could include the Iberian magpie (*Cyanopica cooki*), Iberian grey shrike (*Lanius meridionalis*) and ortolan bunting (*Emberiza hortulana*). Iberian magpies are a typical element of Iberian avifauna and have been split from their Asian conspecific based on genetic evidence (Kryukov et al., 2004). The species is highly valued by birdwatchers as a flagship species for Mediterranean agrosilvopastoral systems (e.g. dehesas) (see Q 5.7). Iberian magpies roam in groups in open woodland with grassy clearings, including orchards and olive groves. Their diet consists mainly of acorns and pine nuts, supplemented by invertebrates, soft fruits and berries, and also human-provided scraps in parks and towns. They are in the same feeding niche as red-vented bulbul.

3: Hybridisation

Hybridisation with common bulbul (*P. barbatus*) could potentially occur in the risk assessment area. However, hybrids have not yet been reported. Also, common bulbul is one of the commonest birds in Africa but it only recently expanded its range and started breeding in southern Spain around Tarifa so this risk of hybridisation is currently limited.

4: Predation

Red-vented bulbul is known to be a predator of insects and smaller (or juvenile) vertebrate prey like geckos and lizards (Thibault et al., 2018c). Using Speybroeck et al. (2016) and data compiled on native reptiles on Mediterranean islands Ficetola et al. (2014) we compiled a list of lizards and geckos that could potentially be predated upon. A lot of those have restricted, endemic ranges within Mediterranean islands. These include: Greek Algyroides (*Algyroides moreoticus*) (endemic), Dalmatian Algyroides (*A. nigropunctatus*) and Peloponnese slow worm (*Anguis cephallonica*) on Ionian islands; Sicilian wall lizard (*Podarcis waglerianus*) (endemic) on Sicily and the threatened Aeolian wall lizard (*Podarcis raffoneae*) (endemic) on some smaller Aeolian islets; Milos wall lizard (*Podarcis milensis*) (endemic), Balkan green lizard (*Lacerta trilineata hansschweizeri*) (endemic subspecies), Skyros wall lizard (*Podarcis gaigeae*) (endemic) and Erhard's wall lizard (*Podarcis erhardii*) on the Aegean islands; Cretan wall lizard (*Podarcis cretensis*) (endemic), Kotschy's gecko (*Mediodactylus kotschyi bartoni*) (endemic subspecies), Balkan green lizard (*L. trilineata polylepidota*) (endemic subspecies) and Pori wall lizard (*Podarcis levendis*) (endemic) on Crete; Pygmy algyroides (*A. fitzingeri*) (endemic), Tyrrhenian wall lizard (*Podarcis tiliguerta*) (endemic) and European leaf-toad gecko (*Euleptes europaea*) (endemic) on the Thyrrenian islands; Ibiza wall lizard (*Podarcis pityusensis*) (endemic) and Lilford's wall lizard (*Podarcis lilfordi*) (endemic) on the Balearic islands; Kotschy's gecko (*Mediodactylus kotschyi*) on Cyprus and the eastern Mediterranean; the more widespread Moorish gecko (*Tarentola mauritanica*) and Turkish gecko (*Hemidactylus turcicus*) across the Mediterranean. Likewise, the list of insects (Lepidoptera, Coleoptera, Orthoptera) that could be predated upon by bulbuls is very long. Considering documented predation on monarch butterfly (*Danaus plexippus*) on Hawaii (see Q 5.1), this species could also be impacted in southern Spain where it is established yet rare (Gil 2006; Lafranchis 2004). Also similar species of Nymphalidae (and other families such as Papilionidae) with conspicuous colours and/or conspicuous larvae could be impacted in Spain and the Mediterranean, such as the African queen (*Danaus chrysippus*) but documented information is lacking for the risk assessment area.

However, although in theory population declines of native insects and reptiles are possible, it is unlikely predation on (mostly nocturnal) geckos or lizards would effectively lead to species extinctions and there are no documented examples of extinctions caused by red-vented bulbuls elsewhere in its invasive range. Hence, score is moderate but with low confidence because of lack of specific impact studies relating to the risk assessment area.

Qu. 5.4. How important is decline in conservation value with regard to European and national nature conservation legislation caused by the organism currently in the risk assessment area?

including the following elements:

- native species impacted, including red list species, endemic species and species listed in the Birds and Habitats directives
- protected sites impacted, in particular Natura 2000
- habitats impacted, in particular habitats listed in the Habitats Directive, or red list habitats

• the ecological status of water bodies according to the Water Framework Directive and environmental status of the marine environment according to the Marine Strategy Framework Directive

RESPONSE	minimal **minor** moderate major massive	**CONFIDENCE**	**low** medium high

Comment:

We found no documented impact information for the population around Valencia, which is breeding in suburban gardens and sympatric with the more widely established red-whiskered bulbul (*P. jocosus*) (personal communication Carlos Gutiérrez-Expósito, 2018), nor the individuals in Torremolinos, Málaga (Spain) or the population on Fuerteventura which established around 2000. Currently, in the risk assessment area, there is no evidence that red-vented bulbul occurs or is spreading in high conservation value habitats. As no studies have been conducted on this subject, the confidence on this response is low, however it is generally difficult to provide proof of impact in early invasion stages.

Qu. 5.5. How important is decline in conservation value with regard to European and national nature conservation legislation caused by the organism likely to be in the future in the risk assessment area?
including the following elements: • native species impacted, including red list species and species listed in the Birds and Habitats directives • protected sites impacted, in particular Natura 2000 • habitats impacted, in particular habitats listed in the Habitats Directive, or red list habitats • the ecological status of water bodies according to the Water Framework Directive and environmental status of the marine environment according to the Marine Strategy Framework Directive

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	low **medium** high

Comment:

Based on what is known of its ecological amplitude and habitat characteristics, the red-vented bulbul could potentially establish and spread in a variety of habitats, mostly (peri)urban habitats as is the case in Torremolinos (Malagá) and in Valencia where the species frequents gardens in family groups. Here, impact (e.g. through competition) would occur on rather common species (see Q 5.3). However, if the species becomes more widespread, also conservation value habitats could be invaded where the bulbuls could affect species of concern. Habitats protected by the Habitats Directive which could potentially be invaded and impacted upon through seed dispersal of invasive alien plants include sub-Mediterranean and temperate scrub, Mediterranean arborescent matorral (maquis), Mediterranean sclerophyllous forests (e.g. wild olive woodland, cork-oak forests), garrigue (also known as phrygana in the eastern Mediterranean) and maquis shrubland, which is a complex of several possible vegetation types but characterized by densely growing evergreen shrubs. Several of these vegetation types have unique representation as specific habitats of the Habitats Directive on islands in the Mediterranean (e.g. Tyrrhenian islands, Ionian islands, Cyprus, Malta) (based on European Commission 2013). The Mediterranean scrub biome is also home to a number of breeding birds that could be affected by the red-vented bulbul through competition for nesting space and food. These include a range of songbirds (shrikes, warblers, buntings etc.) and include many species protected by the Birds Directive as well as species listed as vulnerable on the IUCN Red List e.g. Iberian grey shrike (*Lanius meridionalis meridionalis*), bunting species such as ortolan bunting (*Emberiza hortulana*) or commoner species of similar habitats like European stonechat (*Saxicola rubicola*). Currently, the red-vented bulbul is present in Valencia (established) and Torremolinos (not established but status remains unclear) (Spain), both areas with typical Mediterranean vegetation that fall within the modelled distribution area for the species. The vulnerable species listed above are also present in that area. Other vertebrate species that could potentially be affected include geckos and lizards, many of which are endemic or have very restricted ranges and are listed on the Annexes II and IV of the EU Habitats Directive.

Ecosystem Services impacts

Qu. 5.6. How important is the impact of the organism on provisioning, regulating, and cultural services in its non-native range excluding the risk assessment area?

- For a list of relevant services use the CICES classification V5.1 provided as an annex.
- Impacts on ecosystem services build on the observed impacts on biodiversity (habitat, species, genetic, functional) but focus exclusively on reflecting these changes in relation to their links with socio-economic well-being.
- Quantitative data should be provided whenever available and references duly reported.
- In absence of specific studies or other direct evidences this should be clearly stated by using the standard answer “No information has been found on the issue”. This is necessary to avoid confusion between “no information found” and “no impact found”.

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	low **medium** high

Comment:

The red-vented bulbul is a known pest species on horticultural and agricultural produce outside its native range, e.g. in plant nurseries or on fruits and vegetables (see Qu. 5.9). It has become a pest in agriculture and an active disperser of invasive alien plants (Shine et al., 2003). In 1999, Decree N°171CM, prepared by the Délégation à l'Environnement listed red-vented bulbul among three other alien birds as a threat to biodiversity in French Polynesia (Shine et al., 2003).

1 / Provisioning ecosystem services: The species may have an impact on provisioning ecosystem services such as cultivated terrestrial plants grown for nutritional purposes and as ornamentals. The red-vented bulbul can feed on unripe fruits and buds in large flocks (Fox, 2011), and as a consequence, damage to cultivated plants is the most frequently reported impact of the red-vented bulbul in its alien range. However, these studies were conducted in a limited number of places, such as on Hawaii and in New Caledonia (Thibault et al., 2018b). In a global literature review, Thibault et al. (2018c) report damage to at least 52 plant species belonging to 25 families with 67% (35 species) being food plants (fruits and legumes such as papayas, bananas, lychee, mangos, spinach, cucumber, courgette, aubergine, dragon fruit) and 33% (17 species) being ornamental plant species (e.g. orchids, *Hibiscus* spp.). These numbers are underestimations as many reports of consumption by red-vented bulbul do not consider the type of impact (damage to production or seed dispersal). The impact of the red-vented bulbul appears to be particularly serious on Oahu (Hawaii), where the birds are reported consuming several species of fruits, vegetables and flowers, leading to considerable economic losses. In New Caledonia, significant impacts have been recorded for some crops and plant nurseries with up to 35% losses (Caplong and Barjon, 2010). Significant impacts were observed on production fruit trees, with no less than 35% loss in attacked orchards. Damage was recorded on lychee and peach production but also on papaya and other fruits, sometimes up to the total destruction of the orchard (Metzdorf and Brescia, 2008). Moreover, damage to red fruits in general (tomatoes, strawberries) was reported with losses on tomato production of 500 kg per week as is damage to buds and flowers (Metzdorf and Brescia, 2008). Damage to aubergine crops has also been reported, but also other crops such as dragon fruit (*Pitaya sp.*) (Thouzeau-Fonseca, 2013). Conversely, the red-vented bulbul is not considered an agricultural pest in Fiji (Watling, 1979), nor in Houston (Texas, USA) where it was found to consume mainly introduced tropical plant species (Brooks, 2013).

2 / Cultural ecosystem services: Impacts on cultural ecosystem services may include disturbance of the heritage of isolated island ecosystems in case red-vented bulbul establishment and spread comes at the expense of endemic species. This could occur through changes in abundance of native bird species driving a spatial reassembly of the avifauna. Also, this would especially occur when the species would cause changes in vegetation by promoting seed dispersal of unwanted invasive alien plant species, which could alter ecosystem structure and species composition (Watling 1979; Blanvillain, et al., 2003; Thibault et al. 2019) and make landscapes less attractive for recreation and wildlife watching, or impact the qualities of ecosystems with cultural importance. For instance, a study conducted by Spotswood et al. (2013) in French Polynesia showed that the red-vented bulbul prefers the fruit of a highly invasive tree (*Miconia calvescens*) over that of three other species (one alien, two native). Also in New Caledonia, the red-vented bulbul showed preference for non-native species, including the highly invasive *S. terebinthifolius* (Thibault et al., 2018b). In addition, gut transition led to enhanced germination rates and could represent an "invasional meltdown", a mutualistic relationship between invasive seed dispersers and invasive plant species leading to higher numbers/faster spread rates of both species and possibly major conservation issues, particularly in ecosystems that host a large number of endemic plant species (Thibault et al., 2018b).

These impacts are mostly documented on Pacific islands, not in other areas. In addition, no studies have addressed ecosystem services impact specifically, but there is evidence of economic and ecosystem impact, hence we score confidence as medium.

Qu. 5.7. How important is the impact of the organism on provisioning, regulating, and cultural services currently in the different biogeographic regions or marine sub-regions where the species has established in the risk assessment area (include any past impact in your response)? ● See guidance to Qu. 5.6.

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high

Comment:

No information has been found on ecosystem services impact of the red-vented bulbul where it established in the RA area (Spain). The population in Valencia is breeding in gardens of urbanized areas surrounding the city (personal communication Carlos Gutiérrez-Expósito, 2018).

1 / Provisioning ecosystem services: there may be impacts on provisioning ecosystem services by damage to plants, fruits and legumes grown in gardens or commercial produce (e.g. citrus and tomato around Valencia) but this would probably be very localized (see Q 5.11).

2 / Cultural ecosystem services: If the red-vented bulbul would establish on isolated Mediterranean islands harbouring endemic species, similar effects could occur as documented on Pacific island ecosystems through decreasing ecosystem qualities for observational interactions such as wildlife watching, birding, ecotourism etc. (see Qu. 5.6). As an example, through competition with native bird species a red-vented bulbul invasion could transform avian assemblages in Iberia (see Qu 5.3). Maritime pine (*Pinus pinaster*) forests are a protected European Habitat (Annex I habitat type 2270 - wooded dunes with *P. pinea* and/or *P. pinaster*), and dehesa (Annex I habitat type 6310 - Dehesas with evergreen *Quercus* spp), open parklands of *Quercus ilex rotundifolia* used for cattle grazing, are a well-known, traditional, culturally highly valued landscape in rural Iberia. A large proportion of the surface area (35.3%) of this typically Mediterranean agrosilvopastoral ecosystem is classified by UNESCO as a Biosphere Reserve (Dehesas de Sierra Morena) since 2002 and Sierra Morena is also part of the Natura 2000 network (site code ES0000090) of protected areas since 1997 (Massot 2016). This ecosystem contains a number of typical bird species that are highly valued by birdwatchers (see Qu 5.3). The presence of large populations of bulbuls, which often flock together in noisy family groups, could cause changes in such valued native bird assemblages, including in parks and gardens where people go to appreciate native wildlife.

Qu. 5.8. How important is the impact of the organism on provisioning, regulating, and cultural

services likely to be in the different biogeographic regions or marine sub-regions where the species can establish in the risk assessment area in the future?

- See guidance to Qu. 5.6.

RESPONSE	minimal minor moderate **major** massive	**CONFIDENCE**	low **medium** high

Comment:

Within the Mediterranean biogeographic region, the red-vented bulbul will likely impact on several ecosystem services, including:

- Provisioning - Biomass - Cultivated terrestrial plants - Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes
- Regulation & Maintenance - Regulation of physical, chemical, biological conditions - Lifecycle maintenance, habitat and gene pool protection - Seed dispersal
- Cultural - Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting - Physical and experiential interactions with the natural environment - Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions
- Cultural - Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting - Physical and experiential interactions with the natural environment - Intellectual and representative interactions with natural environment - Characteristics of living systems that enable aesthetic experiences
- Cultural - Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting - Other biotic characteristics that have a non-use value - Characteristics or features of living systems that have an option or bequest value

Besides crop or ornamental plant damage in the endangered area in the Mediterranean (including citrus, tomatoes and strawberry relevant to Iberia, see Qu 5.6), the red-vented bulbul also impacts seed dispersal and could act as a vector for seeds of invasive plant species causing changes in ecosystem structure and species composition of vulnerable Mediterranean island ecosystems harbouring endemic species (for examples see Qu 5.3). This could impact on culturally valued qualities of ecosystems (structure, species composition etc.) that make them attractive to ecotourism, recreation, wildlife watching, or that have cultural and intrinsic value, particularly on Mediterranean islands.

Lastly, since the red-vented bulbul could have an impact on the distribution of less territorial native species, it could alter the species composition in the invasive range, impacting on several cultural ecosystem services as listed above (see Qu 5.6, 5.7).

Economic impacts

Qu. 5.9. How great is the overall economic cost caused by the organism within its current area of distribution (excluding the risk assessment area), including both costs of / loss due to damage and the cost of current management.

- Where economic costs of / loss due to the organism have been quantified for a species anywhere in the world these should be reported here. The assessment of the potential costs of / loss due to damage shall describe those costs quantitatively and/or qualitatively depending on what information is available. Cost of / loss due to damage within different economic sectors can be a direct or indirect consequence of the earlier-noted impacts on ecosystem services. In such case, please provide an indication of the interlinkage.

RESPONSE	minimal minor moderate **major** massive	**CONFIDENCE**	low **medium** high

Comment:

As stated in Qu. 5.8, the red-vented bulbul is considered an agricultural pest species in several parts of its invasive range. The estimated value of the damage to Oahu's Orchid industry in 1989 was $300,000 (Fox, 2011) when the red-vented bulbul together with the Japanese white-eye (*Zosterops japonicus*) reportedly destroying up to 75% of Hawaiian *Dendrobium* orchid and *Anthurium* plantations. This also prompted investigations into chemical repellents to keep the birds off orchid plantations (Cummings et al., 1994). Also in New Caledonia, Thibault et al. (2019) report an economic loss of approximately $18,355 USD for September 2016 alone in tomato plots.

The species is a well-known agricultural pest species in many parts of the world and there are many, although mostly anecdotal, records of economic damages. Many more probably remain unreported, so we assume yearly damages can easily mount up to more than € 1,000,000 and scored major.

Qu. 5.10. How great is the economic cost of / loss due to damage (excluding costs of management) of the organism currently in the risk assessment area (include any past costs in your response)?

- Where economic costs of / loss due to the organism have been quantified for a species anywhere in the EU these should be reported here. Assessment of the potential costs of damage on human health, safety, and the economy, including the cost of non-action. A full economic assessment at EU scale might not be possible, but qualitative data or different case studies from across the EU (or third countries if relevant) may provide useful information to inform decision making. In absence of specific studies or other direct evidences this should be clearly stated by using the standard answer "No information has been found on the issue". This is necessary to avoid confusion between "no information found" and "no impact found". Cost of / loss due to damage within different economic sectors can be a direct or indirect consequence of the earlier-noted impacts on ecosystem services. In such case, please provide an indication of the interlinkage.

RESPONSE	**minimal** minor moderate major	**CONFIDENCE**	**low** medium high

	massive		

Comments:

No information has been found on the issue.

Qu. 5.11. How great is the economic cost of / loss due to damage (excluding costs of management) of the organism likely to be in the future in the risk assessment area? ● See guidance to Qu. 5.10.

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	low **medium** high

Comments:

Although Thibault et al. (2019) report considerable economic damages outside the native range (e.g. on tomato production, *Hibiscus* and orchids) (see Qu 5.8 and 5.9), Brooks (2013) reports no damage of that kind in Houston and states that flock sizes remain small (average 2.3 birds/flock, range 1–22) compared to the native range which also limits the potential for damage. Also, although this would involve extra costs, bulbul damage can be mitigated using nets, repellents or other methods (see Annex IV). Spain is an important producer of fresh fruit and vegetables which are mostly exported to other EU Member States and the United Kingdom (https://wits.worldbank.org/), with the area of Valencia where the species is currently established as an important citrus region. Tomatoes are also of great economic importance in Spain, as it is the world's 8th producer, with a production of 5,163 million kilograms, grown on an area of 60,852 hectares (www.hortoinfo.es). In Torremolinos, Málaga, the main crops of economic importance that could potentially be impacted include almonds, sunflowers and olives (Massot 2016), apart from small agricultural produce of vegetables in gardens. In the case where the red-vented bulbul establishes more widely in the risk assessment area, economic damages could occur. However, they would probably be localized and context dependent. Also, methods are available to mitigate or prevent bird damages to sensitive crops (e.g. Tracey et al., 2007).

Another vulnerable receptor is the orchid industry, but damage to the orchid industry seems unlikely, given that most orchids in the risk assessment area are produced in The Netherlands in greenhouses, which is outside of the predicted distribution area of the red-vented bulbul and greenhouses are not easily accessible to birds.

In line with other examples of damages outside the native range, but considering the importance of vegetable production in the Mediterranean, we scored moderate.

Qu. 5.12. How great are the economic costs / losses associated with managing this organism currently in the risk assessment area (include any past costs in your response)?

- In absence of specific studies or other direct evidences this should be clearly stated by using the standard answer "No information has been found on the issue". This is necessary to avoid confusion between "no information found" and "no impact found".

RESPONSE	**minimal** minor moderate major massive	CONFIDENCE	low medium **high**

Comments:

The species is currently not under management in the risk assessment area, therefore we can say with confidence the current management cost is minimal.

Qu. 5.13. How great are the economic costs / losses associated with managing this organism likely to be in the future in the risk assessment area?

- See guidance to Qu. 5.12.

RESPONSE	minimal minor **moderate** major massive	CONFIDENCE	**low** medium high

Comments:

There are examples of bulbul eradications on islands using a variety of methods (mostly mist netting with or without supplementary shooting, see Annex IV) (Bunbury et al., 2019, Saavedra & Reynolds, 2019, http://diise.islandconservation.org/). On Fuerteventura, seven birds were caught in 2010 (Saavedra & Reynolds, 2019). However, the costs of such eradication/control efforts are not documented. As a crude proxy, Holmes et al. (2015) provide costings for island eradications of predators, and show that although the implementation costs per ha can be relatively low, the planning phase, isolation and the presence of human habitation (often the case with red-vented bulbul invasions) can add up to great expense. As a comparison, Parkes et al. (2006) estimated that the costs to achieve eradication of common myna (*A. tristis*) from Mangaia (Cook Islands, 5180 ha) with appropriate levels of monitoring would be about NZ$100,000 (c. € 55,000), with 80% of that budget needed for preparation and training and surveillance, including detecting surviving birds. However, here, the method proposed was toxic baiting.

As stated in Qu. 5.11, mitigation of bird damage to produce will also involve additional management costs.

Considering the costs described both above and in Holmes et al. (2015) and assuming the red-vented bulbul would establish more widely in the RA area in suburban mainland areas and/or on islands, we scored moderate but since data on costs from the literature are not species specific, confidence is low.

Social and human health impacts

Qu. 5.14. How important is social, human health or other impact (not directly included in any earlier categories) caused by the organism for the risk assessment area and for third countries, if relevant (e.g. with similar eco-climatic conditions).
The description of the known impact and the assessment of potential future impact on human health, safety and the economy, shall, if relevant, include information on ● illnesses, allergies or other affections to humans that may derive directly or indirectly from a species; ● damages provoked directly or indirectly by a species with consequences for the safety of people, property or infrastructure; ● direct or indirect disruption of, or other consequences for, an economic or social activity due to the presence of a species. Social and human health impacts can be a direct or indirect consequence of the earlier-noted impacts on ecosystem services. In such case, please provide an indication of the interlinkage.

RESPONSE	**minimal** minor moderate major massive	CONFIDENCE	**low** medium high

Comments:

No social or human health impact has been caused by the red-vented bulbul so far. However, red-vented bulbuls in Tahiti have been found to carry the zoonotic disease *Chlamydia sp.* (Blanvillain et al., 2013).

Qu. 5.15. How important is social, human health or other impact (not directly included in any earlier categories) caused by the organism in the future for the risk assessment area. ● In absence of specific studies or other direct evidences this should be clearly stated by using the standard answer “No information has been found on the issue”. This is necessary to avoid confusion between “no information found” and “no impact found”.

RESPONSE	**minimal** minor	CONFIDENCE	**low** medium

	moderate major massive		high

Comments:

See Qu. 5.14. This is not expected to change in the future.

Other impacts

Qu. 5.16. How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)?

RESPONSE	minimal **minor** moderate major massive	**CONFIDENCE**	**low** medium high

Comments:

Dispersal of parasites by red-vented bulbul is not well documented in its alien range. In its native range, the red-vented bulbul is known to host *Isospora* spp. (Boughton et al., 1938), *Menacanthus eurysternus* (Price 1975), *Bruelia guldum* and *Sturnidoecus guldum* (Ansari 1957) and *Pteroherpus pycnonoti* (Constantinescu et al., unpublished). In 1996, Jarvi et al. (2003) detected no avian malaria (*Plasmodium* spp.) in blood smears, and Atkinson et al. (2006) found no evidence of *Plasmodium*, *Trypanosoma*, *Atoxoplasma* or microfilaria. *Plasmodium* is however present in the south Pacific area. Red-vented bulbuls in Tahiti, however, have been found to carry the zoonotic disease *Chlamydia* (Blanvillain et al., 2013).

Qu. 5.17. How important might other impacts not already covered by previous questions be resulting from introduction of the organism?

RESPONSE	**minimal** minor moderate major massive	**CONFIDENCE**	**low** medium high

Comments:

No other possible impacts were found.

Qu. 5.18. How important are the expected impacts of the organism despite any natural control by other organisms, such as predators, parasites or pathogens that may already be present in the risk assessment area?

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	low **medium** high

Comments:

The red-vented bulbul is not particularly vulnerable to predation. In its native range, a study carried out by Zia et al. (2017) found that predation rate on the red-vented bulbul was only 6% in eggs and 9% in nestlings. Predators in the study area included bird species like eagles and barn owl (*Tyto alba*), and rodents like the black rat *(Rattus rattus*). These species or similar species are also present in the risk assessment area, possibly impacting the red-vented bulbul. However, if these only have minor effects in the native range, it is unlikely that their impact will be higher in the introduced range, where they are not used to hunt on the red-vented bulbul. Likely predators of the red-vented bulbul in Valencia and Torremolinos, and by extension the risk assessment area, include the booted eagle (*Hieraaetus pennatus* Gmelin, 1788), Bonelli's eagle (*Aquila fasciata* Vieillot, 1822), the northern goshawk (*Accipiter gentilis* Linnaeus, 1758) and the sparrowhawk (*Accipiter nisus* Linnaeus, 1758). The latter might become the most important predator of the red-vented bulbul in its invasive range, since it mainly preys upon species similar to the red-vented bulbul regarding size, behaviour and habitat, such as the house sparrow (*Passer domesticus* Linnaeus, 1758), common blackbird (*Turdus merula* Linnaeus, 1758), starlings and pigeons. Other birds of prey may take the eggs of the red-vented bulbul, as will mammalian predators like the stone martin (*Martes foina* Erxleben, 1777) and European pine marten (*Martes martes* Linnaeus, 1758). Since the red-vented bulbul nests in trees, it will not be vulnerable to ground predators such as foxes or stoats.

Although the red-vented bulbul is a known host to several parasites in its native range, including *Isospora* spp. (Boughton et al., 1938), *Menacanthus eurysternus* (Price 1975), *Bruelia guldum* and *Sturnidoecus guldum* (Ansari 1957) and *Pteroherpus pycnonoti* (Constantinescu et al., unpublished), no impacts of these parasites on the red-vented bulbul were found.

No information was found on impact of pathogens on the red-vented bulbul.

For more information, see Qu. 3.5.

Qu. 5.19. Estimate the overall impact in the risk assessment area under current climate conditions. In addition, details of overall impact in relevant biogeographical regions should be

provided. Thorough assessment of the overall impact on biodiversity and ecosystem services, with impacts on economy as well as social and human health as aggravating factors, in current conditions.

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	low **medium** high

Response:

See answers to Qu. 5.3, 5.5, 5.8, 5.11, 5.13, 5.15 and 5.16.

Qu. 5.20. Estimate the overall impact in the risk assessment area in foreseeable climate change conditions. In addition, details of overall impact in relevant biogeographical regions should be provided. Thorough assessment of the overall impact on biodiversity and ecosystem services, with impacts on economy as well as social and human health as aggravating factors, under future conditions.

RESPONSE	minimal minor **moderate** major massive	**CONFIDENCE**	low **medium** high

Response:

The proportion of the area suitable for establishment in the Mediterranean biogeographical region is predicted to double under RCP 2.6 and to triple under RCP 4.5 by 2070 (see Qu. 3.14, Annex VII). Therefore, it is moderately likely that the overall impacts will increase too.

RISK SUMMARIES

	RESPONSE	CONFIDENCE	COMMENT
Summarise Introduction*	very unlikely unlikely moderately likely likely **very likely**	low medium **high**	The species is already present in zoological gardens and private collections in multiple countries within the risk assessment area. There is also the possibility that the species is introduced for private bird collections although quantitative data are lacking. Introductions as stowaways are less likely.
Summarise Entry*	very unlikely unlikely moderately likely likely **very likely**	low **medium** high	The red-vented bulbul is kept as a pet and is on display in zoological garden. Escapes and releases have happened before in several countries in the risk assessment area and entry is likely to occur in the future. Stowaways on ships might enter the risk assessment area as well, as the species is established on the Canary islands.
Summarise Establishment*	very unlikely unlikely moderately likely likely **very likely**	low **medium** high	The species already established on at least two locations in the risk assessment area (Spain). The Mediterranean bioregion, including Mediterranean islands, is generally vulnerable to invasion by red-vented bulbul, both under current and future climatic conditions. The red-vented bulbul is most likely to establish in (peri)urban areas with a mediterranean or (semi-)arid climate.
Summarise Spread*	very slowly slowly **moderately** rapidly very rapidly	low **medium** high	The species is classified as a rather sedentary species, showing possible movements depending on environmental conditions. Indeed, spread is limited in Spanish mainland populations, although densities are still limited here and the species has to compete with red-whiskered bulbul. However, the invasion on Fuerteventura, where the species invaded the entire island in a few decades and has shown important range expansion in a short period of time, as well as the Pacific

			invasion, show red-vented bulbul is able to spread moderately rapidly or rapidly in insular contexts.
Summarise Impact*	minimal minor **moderate** major massive	low **medium** high	The red-vented bulbul can impact on native species and ecosystems through competition, frugivory, by spreading alien plants, hybridising with bulbul species, by predating on (in)vertebrates and by pathogen transmission. It is also an agricultural pest in parts of its alien range. However, although declines and niche contraction in sensitive and protected species are possible, no extinctions caused by red-vented bulbul have been documented so far.
Conclusion of the risk assessment (overall risk)	low **moderate** high	low **medium** high	Considering the potential of red-vented bulbul to cause population declines in native species, documented contractions of niches of native species in its alien range but no extinctions, moderate spread capacity, the limited area suitable for establishment in the risk assessment area but presence of sensitive island biota, local and reversible effects on ecosystem services and the potential for moderate economic damages, we scored moderate impact. This score is in line with a recent, global, environmental impact assessment of alien birds using EICAT.

*in current climate conditions and in foreseeable future climate conditions

REFERENCES

Ali, S. & Ripley, S. D. (1971). *Handbook of the birds of India and Pakistan: together with those of Nepal, Sikkim, Bhutan and Ceylon*. Vol. 6, Cuckoo-shrikes to babaxes: synopsis nos. 1064-1271, colour plates 65-72. Oxford University Press.

Ali, S. & Ripley, S. D. (1987). *Handbook of the birds of India and Pakistan together with those of Bangladesh, Nepal, Bhutan and Sri Lanka.* Compact ed. New Delhi: Oxford University Press.

Avifauna Groningen (2000). Waarnemingen 1 juli 1999 tot en met 30 september 1999. *De Grauwe Gors*, 27(4), 252–260.

Azin, F., Nosrati, S. M., Amini, H. (2008). Occurrence of the Red-vented Bulbul *Pycnonotus cafer* on Kish Island, Northeastern Persian Gulf, Iran. *Podoces*, 3(1):105–107.

Baker, J., Harvey, K. J., & French, K. (2014). Threats from introduced birds to native birds. *Emu*, 114(1): 1–12. https://doi.org/10.1071/MU12122

Balakrishnan, P. (2010). Reproductive biology of the Square-tailed Black Bulbul *Hypsipetes ganeesa* in the Western Ghats, India. *Indian Birds*, 5(5), 134–138.

Bates, J. H., Spotswood, E. N., and Russel, J. C. (2014). Foraging behavior and habitat partitioning in sympatric invasive birds in French Polynesia. *Notornis*, 61(1): 35-42.

Bellard, C., Cassey, P., Blackburn, T. M. (2016). Alien species as a driver of recent extinctions. *Biology Letters*, 12:20150623.

Berger, A. J. (1972). *Hawaiian birdlife*. University Press of Hawaii. 1st edition. 270 pp.

Berger, A. J. (1981). *Hawaiian birdlife*. 2nd ed. Univ. Of Hawaii Press, Honolulu.

Bhatt, D. & Kumar, A. (2001). Foraging ecology of Red-vented Bubul *Pycnonotus cafer* in Haridwar, India. *Forktail* 17: 109-110.

Blackburn, T. M., Essl, F., Evans T., et al. (2014). A unified classification of alien species based on the magnitude of their environmental impacts. *PLoS Biol*, 12:e1001850.

Blanvillain, C., Salducci, J.M., Tutururai, G., & Maeura, M. (2003). Impact of introduced birds on the recovery of the Tahiti Flycatcher (*Pomarea nigra*), a critically endangered forest bird of Tahiti. *Biological Conservation*, 109(2): 197-205.

Blanvillain, C., Saavedra, S., Withers, T. (2013). Mission d'enquête sur la contamination de l'avifaune par *Salmonella enteritidis* et d'autre pathogènes des volailles. Rapport SOP/DIREN, Tahiti, French Polynesia.

Brochier, B. Vangeluwe, D. & van den Berg, T. (2010). Alien invasive birds. *Rev. Sci. Tech. Off. Int. Epiz.*, 29 (2): 217-226.

Brooks, D.M. (2013). Ecology, behavior, and reproduction of an introduced population of Red-vented Bulbuls (*Pycnonotus cafer*) in Houston, Texas. *The Wilson Journal of Ornithology*, 125(4): 800-808.

Brundu, G. (2015). Plant invaders in European and Mediterranean inland waters: profiles, distribution, and threats. *Hydrobiologia*, 746:61-79.

Brunel, S., Schrader, G., Brundu, G., Fried, G. (2010). Emerging invasive alien plants for the Mediterranean Basin. *EPPO Bulletin*, 40:219-238.

Bunbury N, Haverson P, Page N, et al. (2019) Five eradications, three species, three islands: overview, insights and recommendations from invasive bird eradications in the Seychelles. In: Veitch, C.R., Clout, M.N., Martin, A.R., Russell, J.C., West, C.J. (eds.). Island invasives: scaling up to meet the challenge, pp. 282–288. Occasional Paper SSC no. 62. Gland, Switzerland: IUCN.

Caplong, P., Barjon, F. (2010). Le Bulbul à ventre rouge, une star méconnue en Nouvelle Caledonie. *La Caledonie Agricole*, 123:22-25.

Cardador, L., Tella, J.L., Anadón, J.D., Abellán, P., Carrete, M. (2019). The European Trade Ban on Wild Birds Reduced Invasion Risks. *Conservation Letters*, 12: e12631. https://doi.org/10.1111/conl.12631

Cassey, P., Hogg, C. J. (2015). Escaping captivity: The biological invasion risk from vertebrate species in zoos. *Biological Conservation*, 181:18–26.

Clapp, R. B., & Sibley, F. C. (1966). Notes on the birds of Tutuila, American Samoa. *Notornis*, 13(3): 157-164.

Cottrell, V. (2017). *Pycnonotus jocosus* (Red-whiskered bulbul). *CABI Invasive Species Compendium datasheet*. Accessed on 23/09/2019.

Cruz, S. S., Reynolds, S. (2019). Eradication and control programmes for invasive mynas (*Acridotheres* spp.) and bulbuls (*Pycnonotus* spp.): defining best practice in managing invasive bird populations on oceanic islands. In: Veitch, C.R., Clout, M.N., Martin, A.R., Russell, J.C., West, C.J. (eds.). Island invasives: scaling up to meet the challenge, pp. 302-308. Occasional Paper SSC no. 62. Gland, Switzerland: IUCN.

Cummings, J. L., Mason, J. R., Otis, D. L. et al. (1994). Evaluation of methiocarb, ziram, and methyl anthranilate as bird repellents applied to *dendrobium* orchids. *Wildlife Society Bulletin* (1973-2006), 22:633-638.

Daigneault, A. & Brown, P. (2013). Invasive species management in the Pacific using survey data and benefit-cost analysis. *In 57th Australian Agricultural and Resource Economic Conference*. Sydney, Australia.

Delacour, J. (1943). A revision of the genera and species of the family Pyconotidae (Bulbuls). *Zoologica*, 28(1): 17-28.

Dhondt, A. (1977). Breeding and postnuptial molt of the red-vented bulbul in Western Samoa. *The Condor*, 79(2), 257-260.

Dickinson, E., Dekker, R. W. R. J., Eck, S., Somadikarta, S. (2002). Systematic notes on Asian birds. 26. Types of the Pycnonotidae. *Zool. Verh. Leiden*, 340: 115-160.

Dickinson, E., Dekker, R. W. R. J. (2002). Systematic notes on Asian birds. 25. A preliminary review of the Pycnonotidae. *Zool. Verh. Leiden*, 340: 93-114.

Dyer, E. E., Redding, D. W., & Blackburn, T. M. (2017). The global avian invasions atlas, a database of alien bird distributions worldwide. *Nature Scientific Data*, 4:170041.

European Commission (2013). Interpretation Manual of European Union Habitats - EUR27. DG Environment, Nature ENV B.3, Brussels

Eubanks, T. L., Behrstock, R. A. & Weeks, R. J. (2006). *Birdlife of Houston, Galveston, and the Upper Texas Coast.* Gulf Coast Books Vol. 10. Texas A&M University Press, 328 pp.

Evans, T., Kumschick, S. & Blackburn, T. M. (2016). Application of the Environmental Impact Classification for Alien Taxa (EICAT) to a global assessment of alien bird impacts. *Diversity and Distributions*, 22:919-931.

Ficetola, G.F., Cagnetta, M., Padoa-Schioppa, E., Quas, A., Razzetti, E., Sindaco, R., Bonardi, A. (2014). Sampling bias inverts ecogeographical relationships in island reptiles. *Global Ecology and Biogeography*, 23:1303–1313. https://doi.org/10.1111/geb.12201

Fishpool, L. & Tobias, J. (2019). Sooty-headed Bulbul (*Pycnonotus aurigaster*). In: del Hoyo, J., Elliott, A., Sargatal, J., Christie, D.A. & de Juana, E. (eds.). *Handbook of the Birds of the World Alive.* Lynx Edicions, Barcelona. (retrieved from https://www.hbw.com/node/57946 on 27 May 2019).

Fox, L. (2011). Red-vented bulbul can alter ecosystems. *Maui News* 6

Freifeld, H. B. (1999). Habitat relationships of Samoan forest birds on Tutuila Island, American Samoa. *Journal of Biogeography*, 26:1191-1213.

Gil, F. (2006). A new host plant for *Danaus plexippus* (Linnaeus, 1758) in Europe. A study of cryptic preimaginal polymorphism within *Danaus chrysippus* (Linnaeus, 1758) in southern Spain (Andalusia) (Lepidoptera, Nymphalidae, Danainae). *Atalanta*, 37(1/2):143-149.

Gill, B. J., Hunt, G. R. & Sirgouant, S. (1995). Red-Vented Bulbul (*Pycnonotus cafer*) In New Caledonia. *Notornis*, 42:214-215.

Gill, F., Donsker, D. & Rasmussen, P. (Eds). 2021. IOC World Bird List (v11.1). doi: 10.14344/IOC.ML.11.1. http://www.worldbirdnames.org/

Gosper, C.R., Stansbury, C.D., Vivian-Smith, G. (2005). Seed dispersal of fleshy-fruited invasive plants by birds: contributing factors and management options. *Diversity and Distributions*, 11:549-558.

Gorman, M. L. (1972). The origin of the avifauna of urban and suburban Suva, Fiji. *Fiji Agricultural Journal*, 34:35-38.

Gregory, G. (2005). *The birds of the State of Kuwait*. Cadeby Books, Grimsby.

Hawaii Invasive Species Council (2017). Red-whiskered bulbul (*Pycnonotus jocosus*). Hawaii, USA: Hawaii Invasive Species Council. http://dlnr.hawaii.gov/hisc/info/invasive-species-profiles/red-whiskered-bulbul/

Hansson, B., Jack, L., Christians, J. K., Pemberton, J. M., Akesson, M., Westerdahl, H., Bensch, S.. & Hasselquist, D. (2007). No evidence for inbreeding avoidance in a great reed warbler population, *Behav Ecol* ,18:157-164.

Heather, B. D. & Robertson, H. A. (1996). *The Field Guide to the Birds of New Zealand.* Viking/Penguin Books Ltd. Auckland.

Holmes, N., Campbell, K., Keitt, B. et al. (2015). Reporting costs for invasive vertebrate eradications. *Biological Invasions*, 17:2913-2925.

Hulme, P. E. (2015). New law risks release of invasive species. *Nature*, 517:21-21.

Hulme, P.E., Brundu, G., Camarda, I., Dalias, P., Lambdon, P., Lloret, F., Medail, F., Moragues, E., Suehs, C., Traveset, A. (2008). Assessing the risks to Mediterranean islands ecosystems from alien plant introductions. Plant invasions: human perception, ecological impacts and management. Leiden: Backhuys Publishers:39-56.

Islam, K., & Williams, R.N. (2000). Red-vented Bulbul (*Pycnonotus cafer*) and Red-whiskered Bulbul (*Pycnonotus jocosus*). *The Birds of North America*, 520:20.

IUCN. 2017. Guidance for interpretation of CBD categories on introduction pathways. Technical note prepared by IUCN for the European Commission.

IUCN 2019. *The IUCN Red List of Threatened Species.* Version 2019-2. <https://www.iucnredlist.org>

Keller, L. F. & Arcese, P. (1998). No evidence for inbreeding avoidance in a natural population of song sparrows (*Melospiza melodia*), *American Naturalist* 152: 380-392.

Khamis, A. (2010). Alien species in Bahrain the overseen threats. *Bahrain Natural History Society Newsletter* 25.

Khan, M. A. R. (1993). The introduced but naturalized avifauna of the United Arab Emirates. *J Bombay Nat Hist Soc*, 90:437–445.

Kottek, M., Grieser, J., Beck, C., Rudolf, B. and Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated. *Meteorol. Z.*, 15, 259-263. DOI: 10.1127/0941-2948/2006/0130.

Kruuk, L. E. B., Sheldon, B. C., Merila, J. (2002). Severe inbreeding depression in collared flycatchers (Ficedula albicollis), *Proc R Soc Lond B*, 269:1581-1589.

Kryukov, A., Iwasa, M.A., Kakizawa, R., Suzuki, H., Pinsker, W. Haring, E. (2004). Synchronic East–West Divergence in Azure-Winged Magpies (*Cyanopica cyanus*) and Magpies (*Pica pica*). *Journal of Zoological Systematics and Evolutionary Research*, 42(4):342-351.

Kumar, A. (2004). Acoustic communication in the Red-vented Bulbul *Pycnonotus cafer*. *Anais de Academia Brasileira de Ciencias (Annals of the Brazilian Academy of Sciences)*, 76(2): 350-358.

Kumar, A. (2010). Communication value of displays and postures in Red-vented Bulbul *Pycnonotus cafer* (Aves: Pycnonotidae). *Journal of Threatened Taxa*, 2(6): 919-929.

Kumschick, S., Nentwig, W. (2010). Some alien birds have as severe an impact as the most effectual alien mammals in Europe. *Biological Conservation*, 143:2757-2762.

Lafranchis, T. (2004). Butterflies of Europe. New Field Guide and Key. Diatheo, Paris, France.

Lambdon, P.W., Pyšek, P., Basnou, C., Hejda, M., Arianoutsou, M., Essl, F., Jarošík, V., Pergl, J., Winter, M., Anastasiu, P. (2008). Alien flora of Europe: species diversity, temporal trends, geographical patterns and research needs. *Preslia*, 80:101-149.

Lendon, A. (1952). Bulbuls in Melbourne. *Emu*, 52(1), 67-68.

Lloret, F., Médail, F., Brundu, G., Camarda, I., Moragues, E., Rita, J., Lambdon, P., Hulme, P.E. (2005). Species attributes and invasion success by alien plants on Mediterranean islands. *Journal of Ecology*, 93:512-520.

Long, J. L. (1981). *Introduced birds of the world*. Universe Books, New York, USA.

Lowe, S., Browne, M., Boudjelas, S., et al. (2004). 100 of the world's worst invasive alien species: a selection from the global invasive species database. ISSG/SSC/IUCN

Linnebjerg, J.F., Hansen, D.M., Bunbury, N., Olesen, J.M. (2010). Diet composition of the invasive red-whiskered bulbul *Pycnonotus jocosus* in Mauritius. *Journal of Tropical Ecology*, 26:347–350.

MacFarlane, A. E., Kelly, D., Briskie, J. V. (2016). Introduced blackbirds and song thrushes: useful substitutes for lost mid-sized native frugivores, or weed vectors? *New Zealand Journal of Ecology*, 40:80-87.

Martin-Albarracin, V. L., Amico, G. C., Simberloff, D. et al. (2015). Impact of non-native birds on native ecosystems: a global analysis. *PLoS One*, 10:e0143070.

Massot, A. (2016). Research for AGRI Committee - Agriculture in Andalusia. Directorate-General for internal policies policy department b: structural and cohesion policies - agriculture and rural development. doi:10.2861/875069

McDonnell, M.J., Stiles, E.W., Cheplick, G.P., Armesto, J.J. (1984). Bird-dispersal of *Phytolacca americana* L. and the influence of fruit removal on subsequent fruit development. *American Journal of Botany*, 71:895-901.

McNeely, J. S. (2001). *An introduction to human dimensions of invasive alien species.* in J. A. McNeely (editor) The Great Reshuffling. IUCN, Gland Switzerland and Cambridge, UK.

Metzdorf, N., Brescia, F. (2008). Impact de l'avifaune et des roussettes sur les productions fruitières en Nouvelle-Calédonie, Etude préliminaire–Etat des lieux et recommandations. IAC/Axe2. Paita Unpublished report

Meyer, J. Y. (1996). Status of *Miconia calvescens* (Melastomataceae), a dominant invasive tree in the Society Islands (French Polynesia).

Mo, M. (2015). The Red-whiskered Bulbul *Pycnonotus jocosus* in Australia–a global perspective, history of introduction, current status and potential impacts. *Australian Zoologist*, 37:461-471.

Nation, B., Nation, H., Hooper, A. (1997). Birds New to Qatar. *Sandgrouse*, 19:56–62.

NBvV (2014). Specifieke houderijrichtlijn Kala buulbuul 2014, versie 1.1 NBvV code F2.17.016.005. Nederlandse Bond van Vogelliefhebbers, commissie Dierenwelzijn & Wetgeving, Bergen op Zoom.

Nowakowski, J.J., Dulisz, B. (2019). The Red-vented Bulbul *Pycnonotus cafer* (Linnaeus, 1766) - a new invasive bird species breeding in Europe. *BioInvasions Records*, 8: 947-952.

Parham, B. E. V. (1955). Birds as pests in Fiji. *Journal of Fijian Agriculture*, 25:9-14.

Parkes, J., Avarua, R. (2006). Feasibility plan to eradicate common mynas (*Acridotheres tristis*) from Mangaia Island, Cook Islands. *Landcare Research*, Lincoln, New Zealand

Pedersen, T. & Aspinall, S. J. (eds.) (2010). *EBRC Annotated Checklist of the birds of the United Arab Emirates*. *Sandgrouse* Supplement 3: 1-96.

Phillipps, Q & Phillipps, K. (2011). *Phillipps' field guide to the birds of Borneo*. John Beaufoy, Oxford. ISBN 978 1 906780 56 2.

Prajapati, S. H., Patel, C. D., Parmar, R. V. & Patel, M. I. (2011). Breeding performance of red-vented bulbul (*Pycnonotus cafer*). *Life Sciences Leaflets*, 11:298-304.

Rana RS, Chand J, Patyal SK (2014) Evaluation of birds as predators of insect pests infesting cauliflower. *J Commun Mobil Sustain Dev*, 9:18–22.

Rana R, Chand J, Patyal S, Sharma K (2017) Studies on the role of insectivorous birds in managing insect pests of cabbage (*Brassica oleracea* var capitata L.). *Int J Farm Sci*, 6:245–253.

Rao, M. S., Ojha, P. R. & Rao R. (2013). Breeding Performance of Red-Vented Bulbul (*Pycnonotus cafer*) in Sikar Region (Rajastan), India. *International Journal of Science and Research*, 2(7):2319-7064.

Rasmussen, P. C. & Anderton, J. C. (2005). *Birds of South Asia: The Ripley Guide*. Smithsonian Institution and Lynx Edicions. p. 338. ISBN 978-8487334672.

Ratnagar, D. (2015). Forced ferocious fights. *Compassionate Friend*, 38:6-8.

Reino, L., Figueira, R., Beja, P., Araújo, M.B., Capinha, C. & Strubbe, D. (2017). Networks of global bird invasion altered by regional trade ban. *Sci. Adv.* 3(11) : e1700783.

Saavedra, S., Maraver, A., Anadón, J. et al. (2015). A survey of recent introduction events, spread and mitigation efforts of mynas (*Acridotheres* sp.) in Spain and Portugal. *Animal Biodiversity and Conservation*, 38:121-127.

Saavedra, S. C., Reynolds, S. (2019). Eradication and control programmes for invasive mynas (*Acridotheres* spp.) and bulbuls (*Pycnonotus* spp.): defining best practice in managing invasive bird populations on oceanic islands. In: Veitch, C.R., Clout, M.N., Martin, A.R., Russell, J.C., West, C.J. (eds.) (2019). Island invasives: scaling up to meet the challenge, pp. 302. Occasional Paper SSC no. 62. Gland, Switzerland: IUCN.

Santos, D.M. (2015). *Pycnonotus jocosus*. En: Fichas de aves introducidas en España. Grupo de Aves Exóticas (SEO/BirdLife). http://seo.org/conocenos/grupos-de-trabajo/grupo-de-aves-exoticas

SEOBirdlife (2017). Solicitamos medidas de control y gestión en Fuerteventura para el bulbul cafre. https://www.seo.org/2017/08/11/solicitamos-medidas-de-control-en-fuerteventura-para-el-bulbul-cafre/

Severinghaus, L. L. & Chi L. (1999). Prayer animal release in Taiwan. *Biological Conservation*, 89: 301–304.

Shalet, J. (2016). India: Guwahati High Court stays bulbul fight, protests erupt in Assam. *International Business Time*, 14-01-2016. http://www.ibtimes.co.uk/india-guwahati-high-court-stays-bulbul-fight-protests-errupt-assam-1537937

Sharpe, R. B. (1909). A Note on *Molpastes magrathi* Whitehead. *Ibis*, 51(2):302–304. doi:10.1111/j.1474-919X.1909.tb05264.x.

Sherman, J. A. & Fall, P. L. (2010). Observations on feeding frequencies among native and exotic birds and fruit bats at *Erythrina variegata* and Dysoxylum trees on American Samoa. In: Haberle, S. G., Stevenson, J., Prebble, M., editors. *Altered ecologies: fire, climate and human influence on terrestrial landscapes.* Canberra: ANU E Press; pp 101-113.

Shieh, B.-S., Lin, Y.-H., Lee, T.-W., Chang, C.-C., Cheng, K.-T. (2006). Pet Trade as Sources of Introduced Bird Species in Taiwan. *Taiwania*, 51(2):81–86.

Shine, C., Reaser, J. K. & Gutierrez, A. T. (eds.) (2003). *Invasive alien species in the Austral Pacific Region: National Reports & Directory of Resources*. Global Invasive Species Programme, Cape Town, South Africa.

Sibley, C. B. & Short, L. L. (1959). Hybridization in some Indian Bulbuls *Pycnonotus cafer* x *P. leucogenys*. *Ibis*, 101(2):177–182. doi:10.1111/j.1474-919X.1959.tb02373.x

Speybroeck, J., Beukema, W., Bok, B., Van Der Voort, J. (2016). Field guide to the amphibians and reptiles of Britain and Europe: Bloomsbury Publishing.

Spotswood, E. N., Meyer, J. Y., Bartolome, J. W. (2012). An invasive tree alters the structure of seed dispersal networks between birds and plants in French Polynesia. *Journal of Biogeography*, 39:2007-2020.

Spotswood, E. N., Meyer, J. Y., Bartolome, J. W. (2013). Preference for an invasive fruit trumps fruit abundance in selection by an introduced bird in the Society Islands, French Polynesia. *Biological Invasions*, 15:2147-2156.

Stimson, J., Berman, M. (1990). Predator Induced Color Polymorphism in *Danaus plexippus* L (Lepidoptera, Nymphalidae) in Hawaii. *Heredity*, 65:401–406.

Stimson, J., Kasuya, M. (2000). Decline in the frequency of the white morph of the monarch butterfly (Danaus plexippus plexippus L., Nymphalidae) on Oahu, Hawaii. *J Lepid Soc*, 54:29–32.

Stuart, C., & Stuart, T. (1999). *Birds of Africa: from seabirds to seed-eaters*. MIT Press.

Tanner, R. (2017). The European and Mediterranean Plant Protection Organization Updates from EPPO. 12th meeting Bern Convention Group of Experts on Invasive Alien Species. Madeira, 2017-06-1/3.

Tershy, B. R., Shen, K. W., Newton, K. M., et al. (2015). The importance of islands for the protection of biological and linguistic diversity. *Bioscience*, 65:592-597.

Thibault, J. C., Martin, J. L., Penloup, A., Meyer, J. Y. (2002). Understanding the decline and extinction of monarchs (Aves) in Polynesian Islands. *Biological Conservation*, 108(2):161-174.

Thibault, M. (2018a). The red vented-bulbul (*Pycnonotus cafer*): invasion dynamics and ecological impacts of an introduced pest bird in New Caledonia and implications for management. Doctoral dissertation Massey University Manawatu, New Zealand.

Thibault, M., Masse, F., Pujapujane, A., Lannuzel, G., Bordez, L., Potter, M. A., ... & Brescia, F. (2018b). “Liaisons dangereuses”: The invasive red-vented bulbul (*Pycnonotus cafer*), a disperser of exotic plant species in New Caledonia. *Ecology and evolution*, 8(18):9259-9269.

Thibault, M., Vidal, E., Potter, M. A., Dyer, E., & Brescia, F. (2018c). The red-vented bulbul (*Pycnonotus cafer*): serious pest or understudied invader? *Biological Invasions*, 20(1):121-136.

Thibault, M., Vidal, E., Potter, M. A., Sanchez, T., & Brescia, F. (2018d). The invasive red-vented bulbul (*Pycnonotus cafer*) outcompetes native birds in a tropical biodiversity hotspot. *PloS one*, 13(2): e0192249.

Thibault M, Vidal E, Potter M, et al. (2019) Invasion by the red-vented bulbul: an overview of recent studies in New Caledonia. In: Veitch, C.R., Clout, M.N., Martin, A.R., Russell, J.C., West, C.J. (eds.) (2019). Island invasives: scaling up to meet the challenge, pp. 309–316. Occasional Paper SSC no. 62. Gland, Switzerland: IUCN.

Thouzeau-Fonseca, C. (2013). Contribution à la gestion d’un oiseau introduit envahissant en Nouvelle-Calédonie, le bulbul à ventre rouge (*Pycnonotus cafer* L.): étude des modalités de piégeage et du comportement alimentaire en milieu naturel. *IAC Production*, Paita, Nouvelle-Calédonie

Tracey, J., Bomford, M., Hart, Q., Saunders, G., & Sinclair, R. (2007). *Managing Bird Damage to Fruit and Other Horticultural Crops*. Bureau of Rural Sciences, Canberra. Australian Government.

Traveset, A., Richardson, D. M. (2006). Biological invasions as disruptors of plant reproductive mutualisms. *Trends in Ecology & Evolution*, 21:208-216.

Traveset, A., Richardson, D. M. (2014). Mutualistic interactions and biological invasions. *Annual Review of Ecology, Evolution, and Systematics*, 45:89-113.

Turbott, E.G. (1956). Bulbuls in Auckland. *Notornis*, 6:185–192.

van den Berg, A.B. & Haas, M. (2013). WP reports. *Dutch Birding*, 35(4):251–262.

Vander Velde, N. (2002). The red-vented bulbul has come to Micronesia. *Aliens*, 16:13-14.

Vander Velde, N., Vander Velde, B. (2013). Known and potential ticks and tick-borne pathogens of Micronesia. *Micronesica*, 1:1-26.

Van Tienderen, P.H. & van Noordwijk, A.J. (1988). Dispersal, kinship and inbreeding in an island population of the Great Tit. *J Evol Biol*, 2: 117-137.

Vijayan, V.S. (1980). Breeding biology of bulbuls, *Pycnonotus cafer* and *Pycnonotus luteolus* with special reference to their ecological isolation. *J. Bom. Nat. Hist. Soc.*, 75:1090-1117.

Vila, M., Siamantziouras, A.S.D., Brundu, G., Camarda, I., Lambdon, P., Medail, F., Moragues, E., Suehs, C.M., Traveset, A., Troumbis, A.Y., Hulme, P.E. (2008). Widespread resistance of Mediterranean island ecosystems to the establishment of three alien species. *Diversity and Distributions*, 14:839-851.

Vila, M., Tessier, M., Suehs, C. M., Brundu, G., Carta, L., Galanidis, A., Lambdon, P., Manca, M., Medail, F., Moragues, E., Traveset, A., Troumbis, A.Y., Hulme, P.E. (2006). Local and regional assessments of the impacts of plant invaders on vegetation structure and soil properties of Mediterranean islands. *Journal of Biogeography*, 33:853-861.

Walker, R., (2008). The Red-vented Bulbul - « Superbird »? *Elepaio*, 68 (9): 73-74.

Watling, D. (1978). Observations on the naturalised distribution of the red-vented bulbul in the pacific, with special reference to the Fiji islands. *Notornis*, 25:109-117.

Watling, D. (1983). The breeding biology of the Red-vented Bulbul *Pycnonotus cafer* in Fiji. *Emu*, 83:173-180.

Watling, R. J. (1978). The ecology of the Red-vented Bulbul in Fiji. University of Cambridge,

Williams, R. N. (1983). Bulbul Introductions on Oahu. *Elapaio* 43(11): 89-90.

Zia, U., Ansari, M. S., Akhter, S. & Rakha, B. A. (2014). Breeding biology of red-vented bulbul (*Pycnonotus cafer*) in the area of Rawalpindi/Islamabad. *The Journal of Animal & Plant Sciences*, 24(2), 656-659.

WEBSITES

http://blogs.thatpetplace.com/thatbirdblog/2010/10/18/the-red-vented-bulbul-an-ideal-softbill-or-non-typical-cage-bird/#.XPotJhYzapo

https://rightpet.com/breed-species/birds/red-vented-bulbul

https://www.vogelspeciaalclub.nl/index.php?option=com_content&view=article&id=61&Itemid=1

https://birdshopeindhoven.nl/kala-buulbuul

https://www.2dehands.be/a/dieren-en-toebehoren/pluimvee/m1417257000-mooi-koppel-kala-bulbul-geringd-2018-met-dna-certificaten.html?c=9b26ed2a557deff636f4f8b9c5b7a618

https://www.softbillsforsale.com/sale/red-vented-bulbul.asp

http://www.birdmagazine.co.uk/c/bulbuls-for-sale

www.hortoinfo.es

Distribution Summary

Please answer as follows:

Yes if recorded, established or invasive
– if not recorded, established or invasive
? Unknown; data deficient

The columns refer to the answers to Questions A5 to A12 under Section A.
For data on marine species at the Member State level, delete Member States that have no marine borders. In all other cases, provide answers for all columns.

Member States and the United Kingdom

	Recorded	Established (currently)	Possible establishment (under current climate)	Possible establishment (under foreseeable climate)	Invasive (currently)
Austria	-	-	-	-	-
Belgium	Yes	-	-	-	-
Bulgaria	-	-	-	-	-
Croatia	-	-	-	-	-
Cyprus	-	-	Yes	Yes	-
Czech Republic	-	-	-	-	-
Denmark	-	-	-	-	-
Estonia	-	-	-	-	-
Finland	-	-	-	-	-
France	-	-	Yes	Yes	-
Germany	-	-	-	-	-
Greece	-	-	Yes	Yes	-
Hungary	-	-	-	-	-
Ireland	-	-	-	-	-
Italy	-	-	?	?	?
Latvia	-	-	-	-	-
Lithuania	-	-	-	-	-
Luxembourg	-	-	-	-	-
Malta	-	-	?	?	?
Netherlands	Yes	-	-	-	-
Poland	-	-	-	-	-
Portugal	-	-	?	?	?
Romania	-	-	-	-	-
Slovakia	-	-	-	-	-
Slovenia	-	-	-	-	-
Spain	Yes	Yes	Yes	Yes	
Sweden	-	-	-	-	-
United Kingdom	-	-	-	-	-

Biogeographical regions of the risk assessment area

	Recorded	Established (currently)	Possible establishment (under current climate)	Possible establishment (under foreseeable climate)	Invasive (currently)
Alpine	-	-	-	-	-
Atlantic	-	-	-	-	-
Black Sea	-	-	-	-	-
Boreal	-	-	-	-	-
Continental	-	-	-	-	-
Mediterranean	-	-	Yes	Yes	-
Pannonian	-	-	-	-	-
Steppic	-	-	-	-	-

ANNEX I Scoring of Likelihoods of Events

(taken from UK Non-native Organism Risk Assessment Scheme User Manual, Version 3.3, 28.02.2005)

Score	**Description**	**Frequency**
Very unlikely	This sort of event is theoretically possible, but is never known to have occurred and is not expected to occur	1 in 10,000 years
Unlikely	This sort of event has not occurred anywhere in living memory	1 in 1,000 years
Moderately likely	This sort of event has occurred somewhere at least once in recent years, but not locally	1 in 100 years
Likely	This sort of event has happened on several occasions elsewhere, or on at least one occasion locally in recent years	1 in 10 years
Very likely	This sort of event happens continually and would be expected to occur	Once a year

ANNEX II Scoring of Magnitude of Impacts

(modified from UK Non-native Organism Risk Assessment Scheme User Manual, Version 3.3, 28.02.2005)

Score	Biodiversity and ecosystem impact	Ecosystem Services impact	Economic impact (Monetary loss and response costs per year)	Social and human health impact, and other impacts
	Question 5.1-5	*Question 5.6-8*	*Question 5.9-13*	*Question 5.14-18*
Minimal	Local, short-term population loss, no significant ecosystem effect	No services affected[7]	Up to 10,000 Euro	No social disruption. Local, mild, short-term reversible effects to individuals.
Minor	Some ecosystem impact, reversible changes, localised	Local and temporary, reversible effects to one or few services	10,000-100,000 Euro	Significant concern expressed at local level. Mild short-term reversible effects to identifiable groups, localised.
Moderate	Measurable long-term damage to populations and ecosystem, but reversible; little spread, no extinction	Measureable, temporary, local and reversible effects on one or several services	100,000-1,000,000 Euro	Temporary changes to normal activities at local level. Minor irreversible effects and/or larger numbers covered by reversible effects, localised.
Major	Long-term irreversible ecosystem change, spreading beyond local area	Local and irreversible or widespread and reversible effects on one / several services	1,000,000-10,000,000 Euro	Some permanent change of activity locally, concern expressed over wider area. Significant irreversible effects locally or reversible effects over large area.
Massive	Widespread, long-term population loss or extinction, affecting several species with serious ecosystem effects	Widespread and irreversible effects on one / several services	Above 10,000,000 Euro	Long-term social change, significant loss of employment, migration from affected area. Widespread, severe, long-term, irreversible health effects.

[7] Not to be confused with “no impact”.

ANNEX III Scoring of Confidence Levels

(modified from Bacher et al., 2017)

Each answer provided in the risk assessment must include an assessment of the level of confidence attached to that answer, reflecting the possibility that information needed for the answer is not available or is insufficient or available but conflicting.

The responses in the risk assessment should clearly support the choice of the confidence level.

Confidence level	**Description**
Low	There is no direct observational evidence to support the assessment, e.g. only inferred data have been used as supporting evidence *and/or* Impacts are recorded at a spatial scale which is unlikely to be relevant to the assessment area *and/or* Evidence is poor and difficult to interpret, e.g. because it is strongly ambiguous *and/or* The information sources are considered to be of low quality or contain information that is unreliable.
Medium	There is some direct observational evidence to support the assessment, but some information is inferred *and/or* Impacts are recorded at a small spatial scale, but rescaling of the data to relevant scales of the assessment area is considered reliable, or to embrace little uncertainty *and/or* The interpretation of the data is to some extent ambiguous or contradictory.
High	There is direct relevant observational evidence to support the assessment (including causality) *and* Impacts are recorded at a comparable scale *and/or* There are reliable/good quality data sources on impacts of the taxa *and* The interpretation of data/information is straightforward *and/or* Data/information are not controversial or contradictory.

ANNEX IV Ecosystem services classification (CICES V5.1, simplified) and examples

For the purposes of this risk assessment, please feel free to use what seems as the most appropriate category / level / combination of impact (Section – Division – Group), reflecting information available.

Section	Division	Group	Examples (i.e. relevant CICES "classes")
Provisioning	**Biomass**	**Cultivated *terrestrial* plants**	Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes; Fibres and other materials from cultivated plants, fungi, algae and bacteria for direct use or processing (excluding genetic materials); Cultivated plants (including fungi, algae) grown as a source of energy *Example: negative impacts of non-native organisms to crops, orchards, timber etc.*
		Cultivated *aquatic* plants	Plants cultivated by in- situ aquaculture grown for nutritional purposes; Fibres and other materials from in-situ aquaculture for direct use or processing (excluding genetic materials); Plants cultivated by in- situ aquaculture grown as an energy source. *Example: negative impacts of non-native organisms to aquatic plants cultivated for nutrition, gardening etc. purposes.*
		Reared animals	Animals reared for nutritional purposes; Fibres and other materials from reared animals for direct use or processing (excluding genetic materials); Animals reared to provide energy (including mechanical) *Example: negative impacts of non-native organisms to livestock*
		Reared *aquatic* animals	Animals reared by in-situ aquaculture for nutritional purposes; Fibres and other materials from animals grown by in-situ aquaculture for direct use or processing (excluding genetic materials); Animals reared by in-situ aquaculture as an energy source *Example: negative impacts of non-native organisms to fish farming*
		Wild plants (terrestrial and aquatic)	Wild plants (terrestrial and aquatic, including fungi, algae) used for nutrition; Fibres and other materials from wild plants for direct use or processing (excluding genetic materials); Wild plants (terrestrial and aquatic, including fungi, algae) used as a source of energy *Example: reduction in the availability of wild plants (e.g. wild berries, ornamentals) due to non-native organisms (competition, spread of disease etc.)*
		Wild animals (terrestrial and aquatic)	Wild animals (terrestrial and aquatic) used for nutritional purposes; Fibres and other materials from wild animals for direct use or processing (excluding genetic materials); Wild animals (terrestrial and aquatic) used as a source of energy *Example: reduction in the availability of wild animals (e.g. fish stocks, game) due to non-native organisms (competition,*

			predations, spread of disease etc.)
	Genetic material from all biota	**Genetic material** from plants, algae or fungi	Seeds, spores and other plant materials collected for maintaining or establishing a population; Higher and lower plants (whole organisms) used to breed new strains or varieties; Individual genes extracted from higher and lower plants for the design and construction of new biological entities *Example: negative impacts of non-native organisms due to interbreeding*
		Genetic material from animals	Animal material collected for the purposes of maintaining or establishing a population; Wild animals (whole organisms) used to breed new strains or varieties; Individual genes extracted from organisms for the design and construction of new biological entities *Example: negative impacts of non-native organisms due to interbreeding*
	Water[8]	**Surface water** used for nutrition, materials or energy	Surface water for drinking; Surface water used as a material (non-drinking purposes); Freshwater surface water, coastal and marine water used as an energy source *Example: loss of access to surface water due to spread of non-native organisms*
		Ground water for used for nutrition, materials or energy	Ground (and subsurface) water for drinking; Ground water (and subsurface) used as a material (non-drinking purposes); Ground water (and subsurface) used as an energy source *Example: reduced availability of ground water due to spread of non-native organisms and associated increase of ground water consumption by vegetation.*
Regulation & Maintenance	**Transformation** of biochemical or physical inputs to ecosystems	**Mediation of wastes or toxic substances** of anthropogenic origin by living processes	Bio-remediation by microorganisms, algae, plants, and animals; Filtration/sequestration/storage/accumulation by microorganisms, algae, plants, and animals *Example: changes caused by non-native organisms to ecosystem functioning and ability to filtrate etc. waste or toxics*
		Mediation of nuisances of anthropogenic origin	Smell reduction; noise attenuation; visual screening (e.g. by means of green infrastructure) *Example: changes caused by non-native organisms to ecosystem structure, leading to reduced ability to mediate nuisances.*
	Regulation of physical, chemical, biological conditions	**Baseline flows and extreme event** regulation	Control of erosion rates; Buffering and attenuation of mass movement; Hydrological cycle and water flow regulation (Including flood control, and coastal protection); Wind protection; Fire protection *Example: changes caused by non-native organisms to ecosystem functioning or structure leading to, for example, destabilisation of soil, increased risk or intensity of wild fires etc.*

[8] Note: in the CICES classification provisioning of water is considered as an abiotic service whereas the rest of ecosystem services listed here are considered biotic.

		Lifecycle maintenance, habitat and gene pool protection	Pollination (or 'gamete' dispersal in a marine context); Seed dispersal; Maintaining nursery populations and habitats (Including gene pool protection) *Example: changes caused by non-native organisms to the abundance and/or distribution of wild pollinators; changes to the availability / quality of nursery habitats for fisheries*
		Pest and disease control	Pest control; Disease control *Example: changes caused by non-native organisms to the abundance and/or distribution of pests*
		Soil quality regulation	Weathering processes and their effect on soil quality; Decomposition and fixing processes and their effect on soil quality *Example: changes caused by non-native organisms to vegetation structure and/or soil fauna leading to reduced soil quality*
		Water conditions	Regulation of the chemical condition of freshwaters by living processes; Regulation of the chemical condition of salt waters by living processes *Example: changes caused by non-native organisms to buffer strips along water courses that remove nutrients in runoff and/or fish communities that regulate the resilience and resistance of water bodies to eutrophication*
		Atmospheric composition and conditions	Regulation of chemical composition of atmosphere and oceans; Regulation of temperature and humidity, including ventilation and transpiration *Example: changes caused by non-native organisms to ecosystems' ability to sequester carbon and/or evaporative cooling (e.g. by urban trees)*
Cultural	**Direct, in-situ and outdoor interactions** with living systems that depend on presence in the environmental setting	**Physical and experiential** interactions with natural environment	Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions; Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions *Example: changes caused by non-native organisms to the qualities of ecosystems (structure, species composition etc.) that make it attractive for recreation, wild life watching etc.*
		Intellectual and representative interactions with natural environment	Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge; Characteristics of living systems that enable education and training; Characteristics of living systems that are resonant in terms of culture or heritage; Characteristics of living systems that enable aesthetic experiences *Example: changes caused by non-native organisms to the qualities of ecosystems (structure, species composition etc.) that have cultural importance*

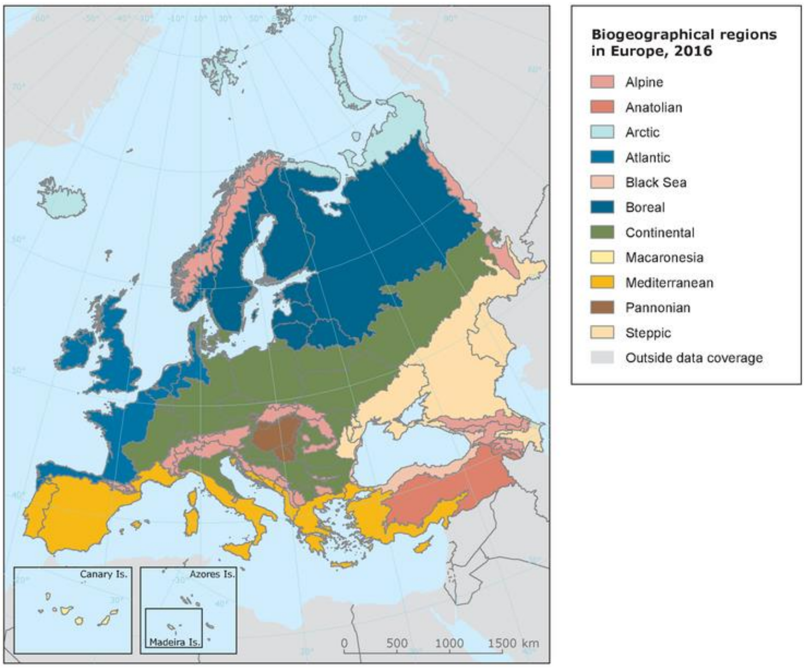
	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	**Spiritual, symbolic** and other interactions with natural environment	Elements of living systems that have symbolic meaning; Elements of living systems that have sacred or religious meaning; Elements of living systems used for entertainment or representation *Example: changes caused by non-native organisms to the qualities of ecosystems (structure, species composition etc.) that have sacred or religious meaning*
		Other biotic characteristics that have a **non-use value**	Characteristics or features of living systems that have an existence value; Characteristics or features of living systems that have an option or bequest value *Example: changes caused by non-native organisms to ecosystems designated as wilderness areas, habitats of endangered species etc.*

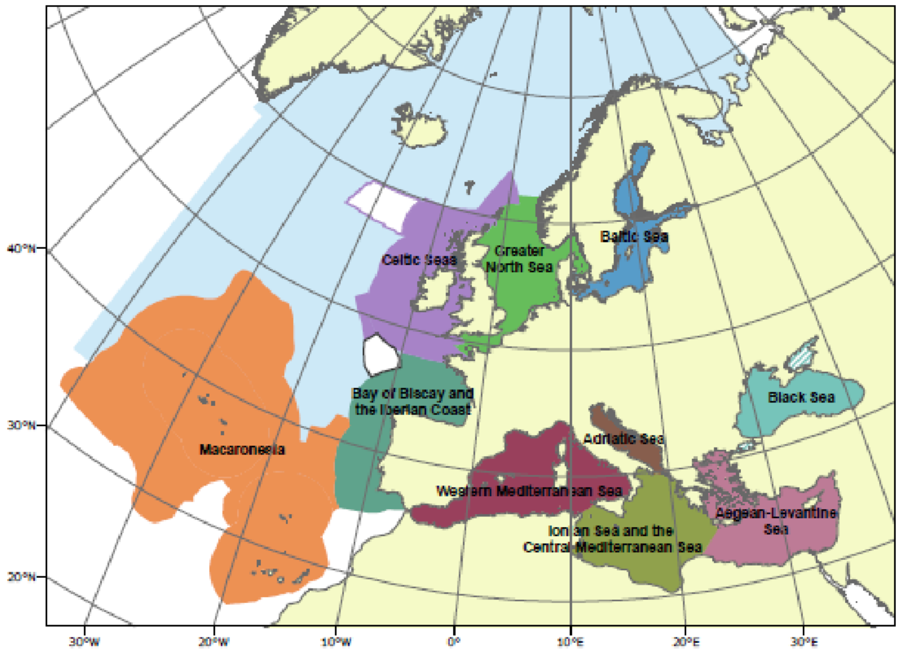
ANNEX V EU Biogeographic Regions and MSFD Subregions

See https://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-in-europe-2 , http://ec.europa.eu/environment/nature/natura2000/biogeog_regions/

and

https://www.eea.europa.eu/data-and-maps/data/msfd-regions-and-subregions-1/technical-document/pdf





ANNEX VI Delegated Regulation (EU) 2018/968 of 30 April 2018

see https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32018R0968

ANNEX VII Projection of climatic suitability for *Pycnonotus cafer* establishment

Björn Beckmann, Martin Thibault, Tim Adriaens, Yasmine Verzelen, Riccardo Scalera, Beth Purse and Dan Chapman

31 October 2019

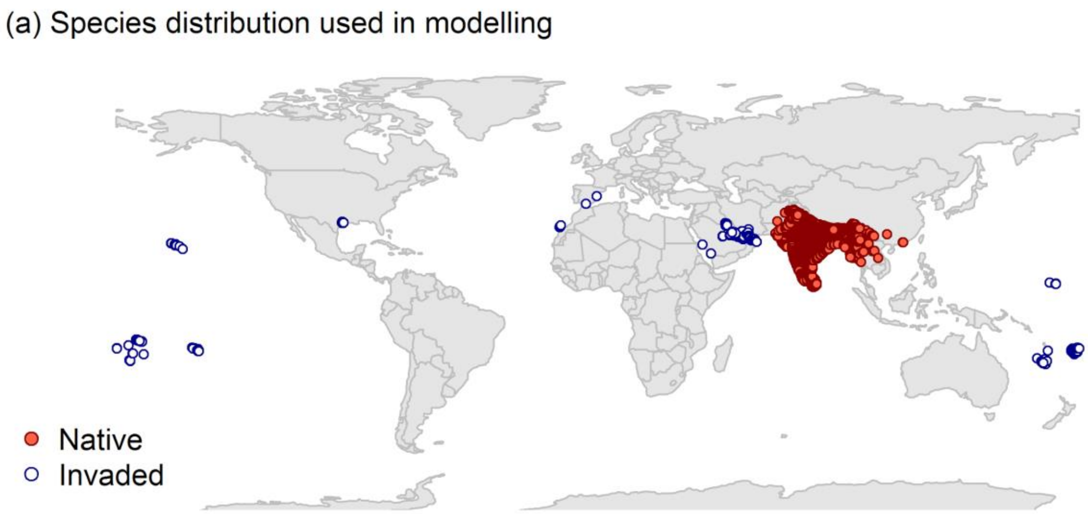
Aim

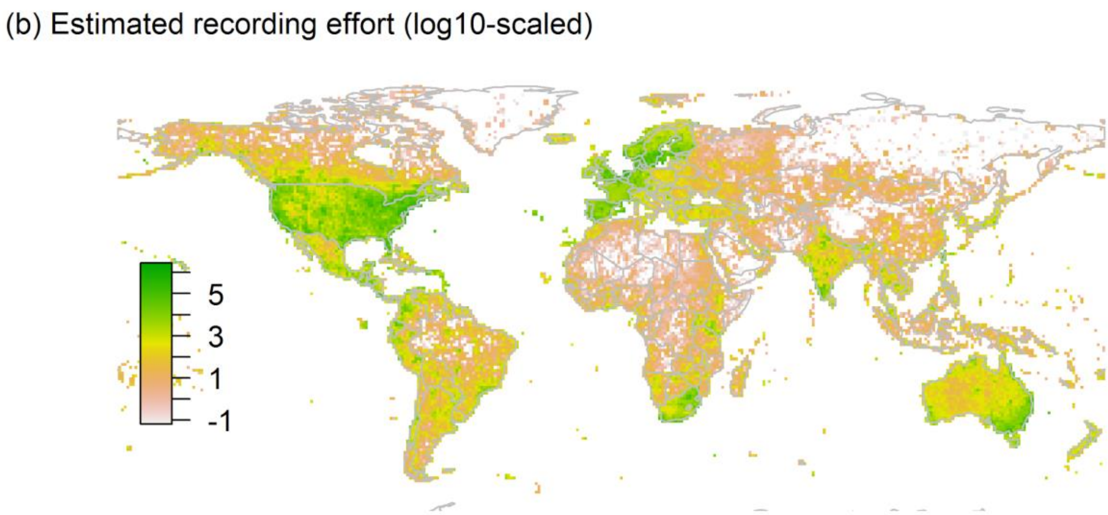
To project the suitability for potential establishment of *Pycnonotus cafer* in Europe, under current and predicted future climatic conditions.

Data for modelling

Species occurrence data were obtained from the Global Biodiversity Information Facility (GBIF) (245716 records), the Biodiversity Information Serving Our Nation database (BISON) (8660 records), iNaturalist (358 records), the Integrated Digitized Biocollections (iDigBio) (42 records), and a small number of additional records from the risk assessment team. We scrutinised occurrence records from regions where the species is not known to be established and removed any dubious records (e.g. fossils, captive records) or where the georeferencing was too imprecise (e.g. records referenced to a country or island centroid) or outside of the coverage of the predictor layers (e.g. small island or coastal occurrences). The remaining records were gridded at a 0.25 x 0.25 degree resolution for modelling, yielding 3381 grid cells with occurrences (Figure 1a). As a proxy for recording effort, the density of Aves records held by GBIF was also compiled on the same grid (Figure 1b).

Figure 1. (a) Occurrence records obtained for *Pycnonotus cafer* and used in the modelling, showing native and invaded distributions. (b) The recording density of Aves on GBIF, which was used as a proxy for recording effort.





Climate data were selected from the 'Bioclim' variables contained within the WorldClim database (Hijmans et al., 2005), originally at 5 arcminute resolution (0.083 x 0.083 degrees of longitude/latitude) and aggregated to a 0.25 x 0.25 degree grid for use in the model.

Based on the biology of *Pycnonotus cafer*, the following climate variables were used in the modelling:

- Annual mean temperature (Bio1)
- Minimum temperature of the coldest month (Bio6)
- Mean temperature of the warmest quarter (Bio10)
- Annual precipitation (Bio12)
- Precipitation of the wettest month (Bio13)
- Precipitation of the driest month (Bio14)

To estimate the effect of climate change on the potential distribution, equivalent modelled future climate conditions for the 2070s under the Representative Concentration Pathways (RCP) 2.6 and 4.5 were also obtained. There represent low and medium emissions scenarios, respectively. The above variables were obtained as averages of outputs of eight Global Climate Models (BCC-CSM1-1, CCSM4, GISS-E2-R, HadGEM2-AO, IPSL-CM5A-LR, MIROC-ESM, MRI-CGCM3, NorESM1-M), downscaled and calibrated against the WorldClim baseline (see http://www.worldclim.org/cmip5_5m).

The following habitat layers were also used:

- Tree cover (Tree): This was estimated from the MODerate-resolution Imaging Spectroradiometer (MODIS) satellite continuous tree cover raster product, produced by the Global Land Cover Facility (http://glcf.umd.edu/data/vcf/). The raw product contains the percentage cover by trees in each 0.002083 x 0.002083 degree grid cell. We aggregated this to the mean cover in our 0.25 x 0.25 degree grid cells.
- Human influence index (HII): As many non-native invasive species associate with anthropogenically disturbed habitats. We used the Global Human Influence Index Dataset of the Last of the Wild Project (Wildlife Conservation Society - WCS & Center for International Earth Science Information Network - CIESIN - Columbia University 2005), which is developed from nine global data layers covering human population pressure (population density), human land use and infrastructure (built-up areas, nighttime lights, land use/land cover) and human access (coastlines, roads, railroads, navigable rivers). The index ranges between 0 and 1 and was ln+1 transformed for the modelling to improve normality.

Species distribution model

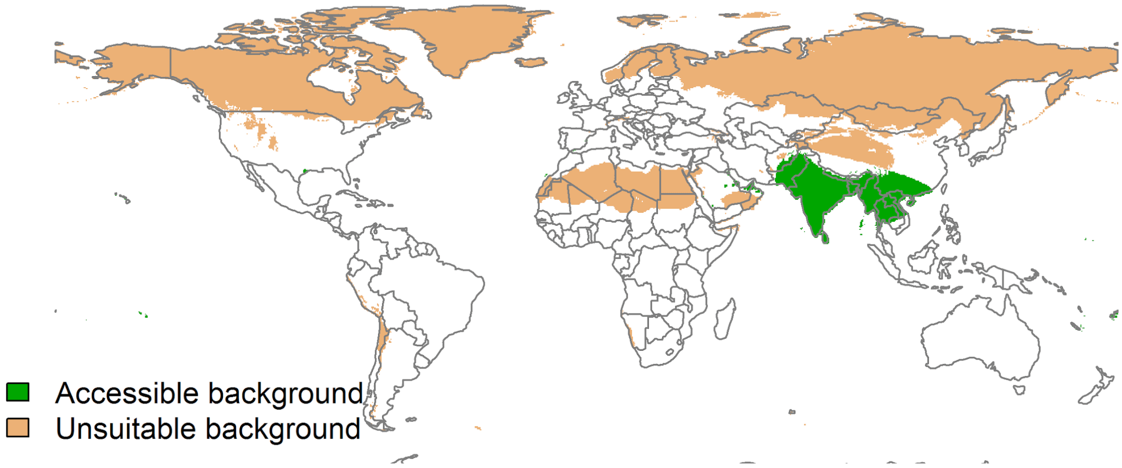
A presence-background (presence-only) ensemble modelling strategy was employed using the BIOMOD2 R package v3.3-7.1 (Thuiller et al., 2019, Thuiller et al., 2009). These models contrast the environment at the species' occurrence locations against a random sample of the global background environmental conditions (often termed 'pseudo-absences') in order to characterise and project suitability for occurrence. This approach has been developed for distributions that are in equilibrium with the environment. Because invasive species' distributions are not at equilibrium and subject to dispersal constraints at a global scale, we took care to minimise the inclusion of locations suitable for the species but where it has not been able to disperse to (Chapman et al., 2019). Therefore the background sampling region included:

- The area accessible by native *Pycnonotus cafer* populations, in which the species is likely to have had sufficient time to disperse to all locations. Based on presumed maximum dispersal distances, the accessible region was defined as a 300km buffer around the native range occurrences; AND
- A 50km buffer around the non-native occurrences, encompassing regions likely to have had high propagule pressure for introduction by humans and/or dispersal of the species; AND
- Regions where we have an *a priori* expectation of high unsuitability for the species so that absence is assumed irrespective of dispersal constraints (see Figure 2). The following rules were applied to define a region expected to be highly unsuitable for *Pycnonotus cafer* at the spatial scale of the model:
    - Annual mean temperature (Bio1) < 4°C
    - Annual precipitation (Bio12) < 4 (i.e. <55mm, as the Bioclim variable is on a natural log scale)

Altogether, only 0.5% of occurrence grid cells were located in the unsuitable background region.

Within the background region, 10 samples of 5000 randomly sampled grid cells were obtained, weighting the sampling by recording effort (Figure 2).

Figure 2. The background from which pseudo-absence samples were taken in the modelling of *Pycnonotus cafer*. Samples were taken from a 300km buffer around the native range and a 50km buffer around non-native occurrences (together forming the accessible background), and from areas expected to be highly unsuitable for the species (the unsuitable background region). Samples were weighted by a proxy for recording effort (Figure 1(b)).



Each dataset (i.e. combination of the presences and the individual background samples) was randomly split into 80% for model training and 20% for model evaluation. With each training dataset, seven statistical algorithms were fitted with the default BIOMOD2 settings and rescaled using logistic regression, except where specified below:

- Generalised linear model (GLM)
- Generalised boosting model (GBM)
- Generalised additive model (GAM) with a maximum of four degrees of freedom per smoothing spline
- Artificial neural network (ANN)
- Multivariate adaptive regression splines (MARS)
- Random forest (RF)
- Maxent

Since the background sample was larger than the number of occurrences, prevalence fitting weights were applied to give equal overall importance to the occurrences and the background. Normalised variable importance was assessed and variable response functions were produced using BIOMOD2's default procedure.

Model predictive performance was assessed by the following three measures:

- AUC, the area under the receiver operating characteristic curve (Fielding & Bell 1997). Predictions of presence-absence models can be compared with a subset of records set aside for model evaluation (here 20%) by constructing a confusion matrix with the number of true positive, false positive, false negative and true negative cases. For models generating non-dichotomous scores (as here) a threshold can be applied to transform the scores into a dichotomous set of presence-absence predictions. Two measures that can be derived from the confusion matrix are sensitivity (the proportion of observed presences that are predicted as such, quantifying omission errors), and specificity (the proportion of observed absences that are predicted as such, quantifying commission errors). A receiver operating characteristic (ROC) curve can be constructed by using all possible thresholds to classify the scores into confusion matrices, obtaining sensitivity and specificity for each matrix, and plotting sensitivity against the corresponding proportion of false positives (equal to 1 - specificity). The use of all possible thresholds avoids the need for a selection of a single threshold, which is often arbitrary, and allows appreciation of the trade-off between sensitivity and specificity. The area under the ROC curve (AUC) is often used as a single threshold-independent measure for model performance (Manel, Williams & Ormerod 2001). AUC is the probability that a randomly selected presence has a higher model-predicted suitability than a randomly selected absence (Allouche et al., 2006).
- Cohen's Kappa (Cohen 1960). This measure corrects the overall accuracy of model predictions (ratio of the sum of true presences plus true absences to the total number of records) by the accuracy expected to occur by chance. The kappa statistic ranges from -1 to +1, where +1 indicates perfect agreement and values of zero or less indicate a performance no better than random. Advantages of kappa are its simplicity, the fact that both commission and omission errors are accounted for in one parameter, and its relative tolerance to zero values in the confusion matrix (Manel, Williams & Ormerod 2001). However, Kappa has been criticised for being sensitive to prevalence (the proportion of sites in which the species was recorded as present) and may therefore be inappropriate for comparisons of model accuracy between species or regions (McPherson, Jetz & Rogers 2004, Allouche et al., 2006).
- TSS, the true skill statistic (Allouche et al., 2006). TSS is defined as sensitivity + specificity - 1, and corrects for Kappa's dependency on prevalence. TSS compares the number of correct forecasts, minus those attributable to random guessing, to that of a hypothetical set of perfect forecasts. Like kappa, TSS takes into account both omission and commission errors, and success as a result of random guessing, and ranges from -1 to +1, where +1 indicates perfect agreement and values of zero or less indicate a performance no better than random (Allouche et al., 2006).

An ensemble model was created by first rejecting poorly performing algorithms with relatively extreme low AUC values and then averaging the predictions of the remaining algorithms, weighted by their AUC. To identify poorly performing algorithms, AUC values were converted into modified z-scores based on their difference to the median and the median absolute deviation across all algorithms (Iglewicz & Hoaglin, 1993). Algorithms with $z < -2$ were rejected. In this way, ensemble projections were made for each dataset and then averaged to give an overall suitability, as well as its standard deviation. The projections were then classified into suitable and unsuitable regions using the 'minROCdist' method, which minimizes the distance between the ROC plot and the upper left corner of the plot (point (0,1)).

We also produced limiting factor maps for Europe following Elith et al. (2010). For this, projections were made separately with each individual variable fixed at a near-optimal value. These were chosen as the median values at the occurrence grid cells. Then, the most strongly limiting factors were identified as the one resulting in the highest increase in suitability in each grid cell.

Results

The ensemble model suggested that suitability for *Pycnonotus cafer* was most strongly determined by Annual mean temperature (Bio1), accounting for 42.9% of variation explained, followed by Mean temperature of the warmest quarter (Bio10) (23.5%), Precipitation of the wettest month (Bio13) (10.2%), Minimum temperature of the coldest month (Bio6) (9.4%), Human influence index (HII) (5.7%), Annual precipitation (Bio12) (5.3%), Precipitation of the driest month (Bio14) (2.2%) and Global tree cover (Tree) (0.8%) (Table 1, Figure 3).

Table 1. Summary of the cross-validation predictive performance (AUC, Kappa, TSS) and variable importance of the fitted model algorithms and the ensemble (AUC-weighted average of the best performing algorithms). Results are the average from models fitted to 10 different background samples of the data.

					variable importance (%)							
Algorithm	AUC	Kappa	TSS	Used in the ensemble	Annual mean temperature (Bio1)	Mean temperature of the warmest quarter (Bio10)	Precipitation of the wettest month (Bio13)	Minimum temperature of the coldest month (Bio6)	Human influence index (HII)	Annual precipitation (Bio12)	Precipitation of the driest month (Bio14)	Global tree cover (Tree)
GLM	0.840	0.488	0.614	yes	60	7	10	9	12	1	1	0
GAM	0.841	0.503	0.616	yes	56	16	7	7	8	4	1	1
ANN	0.847	0.530	0.650	yes	22	31	8	25	5	4	3	2
GBM	0.839	0.512	0.624	yes	42	29	11	4	2	8	3	1
MARS	0.837	0.488	0.614	yes	35	34	16	1	1	11	2	0
RF	0.697	0.478	0.609	no	20	14	13	17	9	10	10	8
Maxent	0.835	0.500	0.613	no	39	34	7	4	7	6	2	2
Ensemble	**0.846**	**0.522**	**0.628**		**43**	**24**	**10**	**9**	**6**	**5**	**2**	**1**

Figure 3. Partial response plots from the fitted models. Thin coloured lines show responses from the algorithms in the ensemble, while the thick black line is their ensemble. In each plot, other model variables are held at their median value in the training data. Some of the divergence among algorithms is because of their different treatment of interactions among variables.

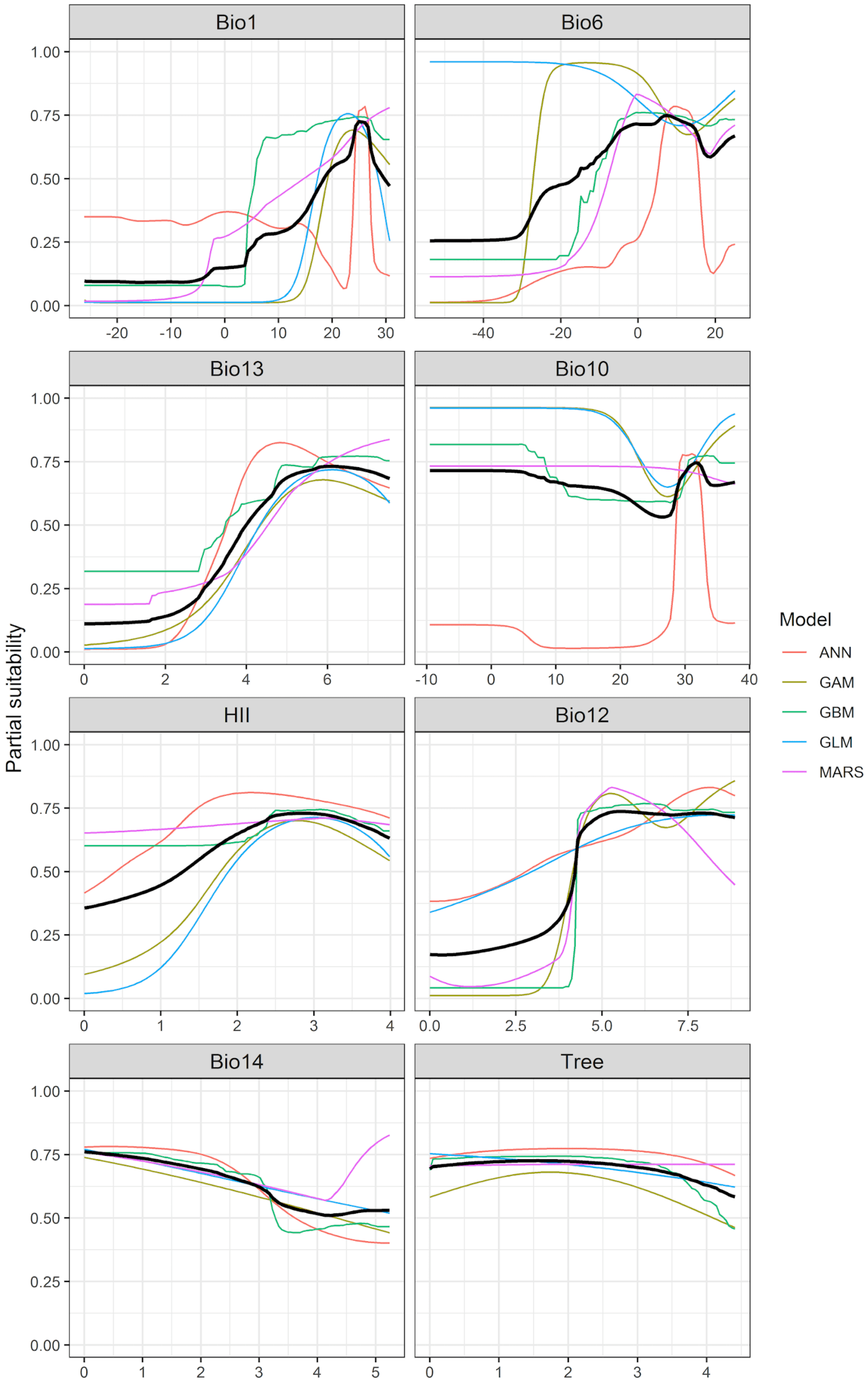


Figure 4. (a) Projected global suitability for *Pycnonotus cafer* establishment in the current climate. For visualisation, the projection has been aggregated to a 0.5 x 0.5 degree resolution, by taking the maximum suitability of constituent higher resolution grid cells. Values > 0.46 may be suitable for the species. Grey areas have missing data in a predictor layer. (b) Uncertainty in the ensemble projections, expressed as the among-algorithm standard deviation in predicted suitability, averaged across the 10 datasets.

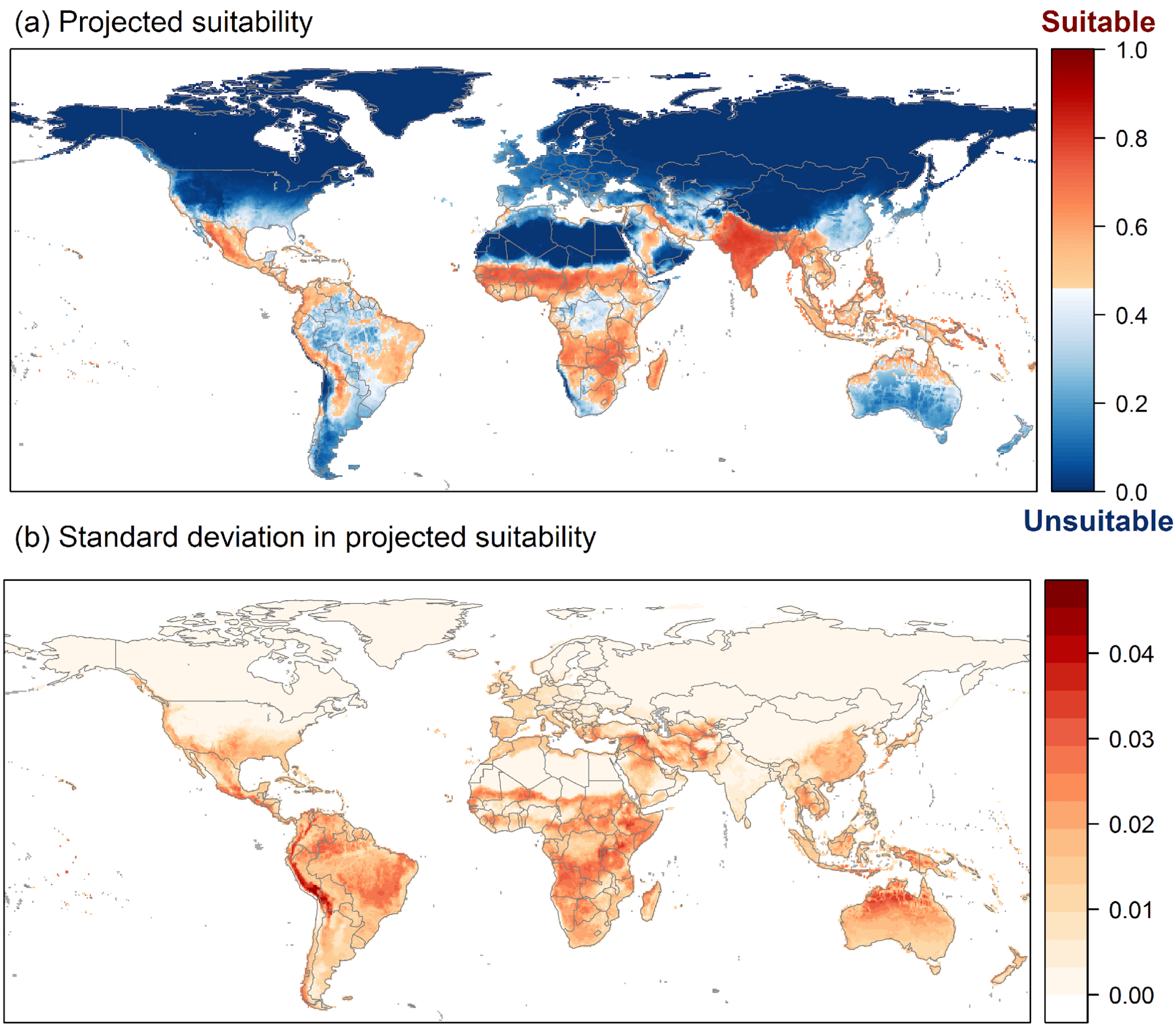


Figure 5. (a) Projected current suitability for *Pycnonotus cafer* establishment in Europe and the Mediterranean region. Grey areas have missing data in a predictor layer. (b) Uncertainty in the ensemble projections, expressed as the among-algorithm standard deviation in predicted suitability, averaged across the 10 datasets.

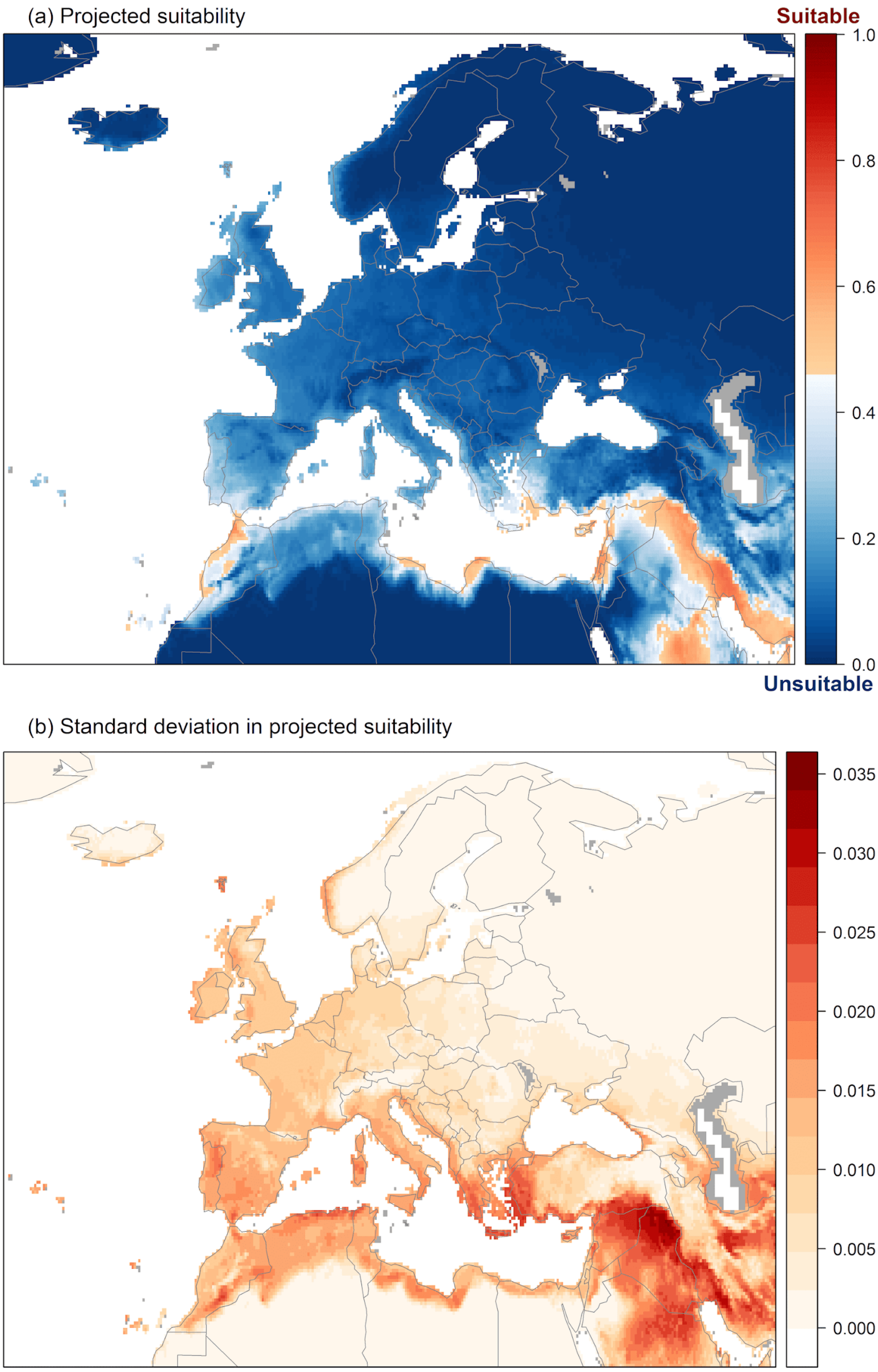


Figure 6. The most strongly limiting factors for *Pycnonotus cafer* establishment estimated by the model in Europe and the Mediterranean region in current climatic conditions.

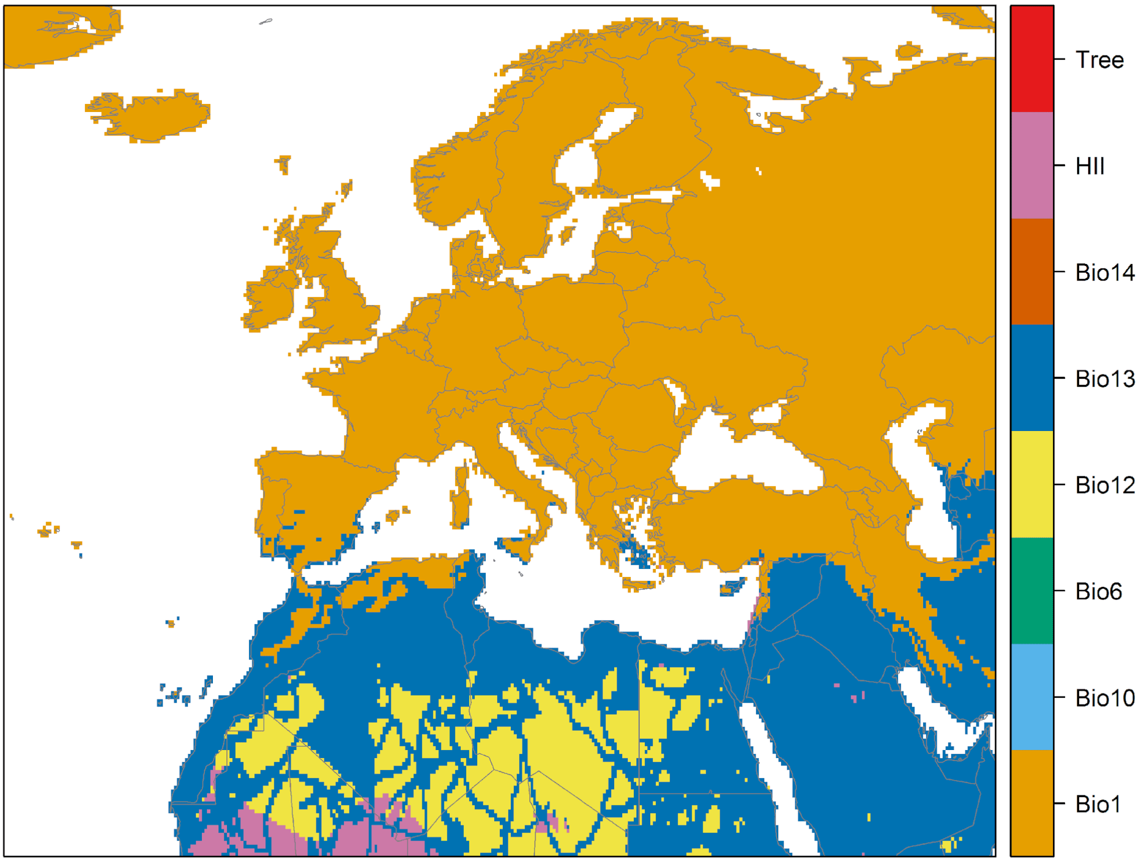
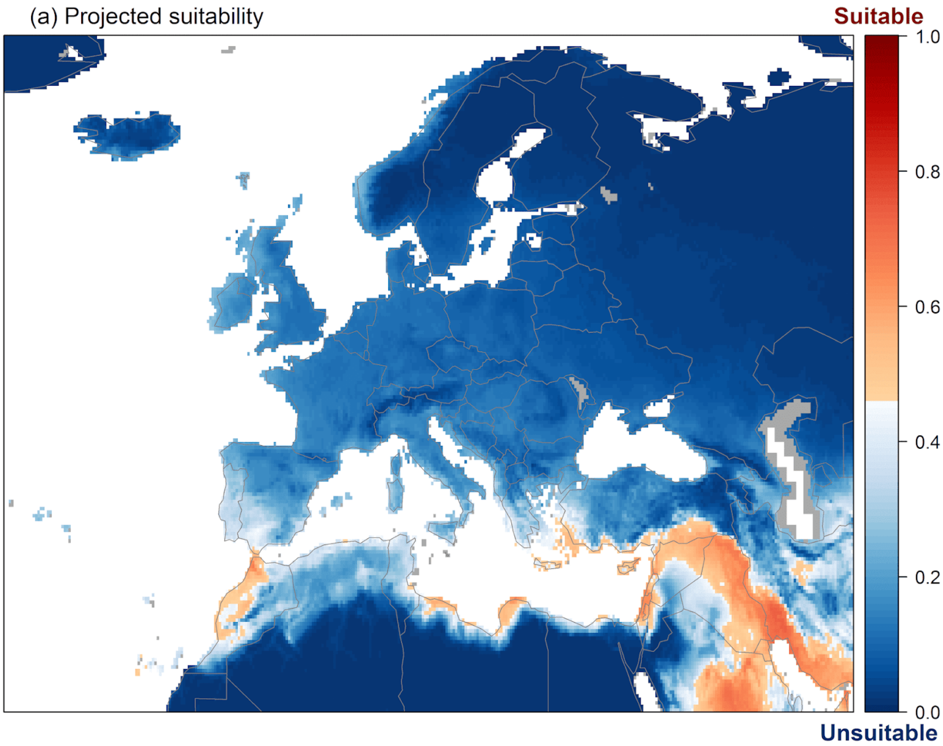


Figure 7. (a) Projected suitability for *Pycnonotus cafer* establishment in Europe and the Mediterranean region in the 2070s under climate change scenario RCP2.6, equivalent to Figure 5. Grey areas have missing data in a predictor layer. (b) Uncertainty in the ensemble projections, expressed as the among-algorithm standard deviation in predicted suitability, averaged across the 10 datasets.



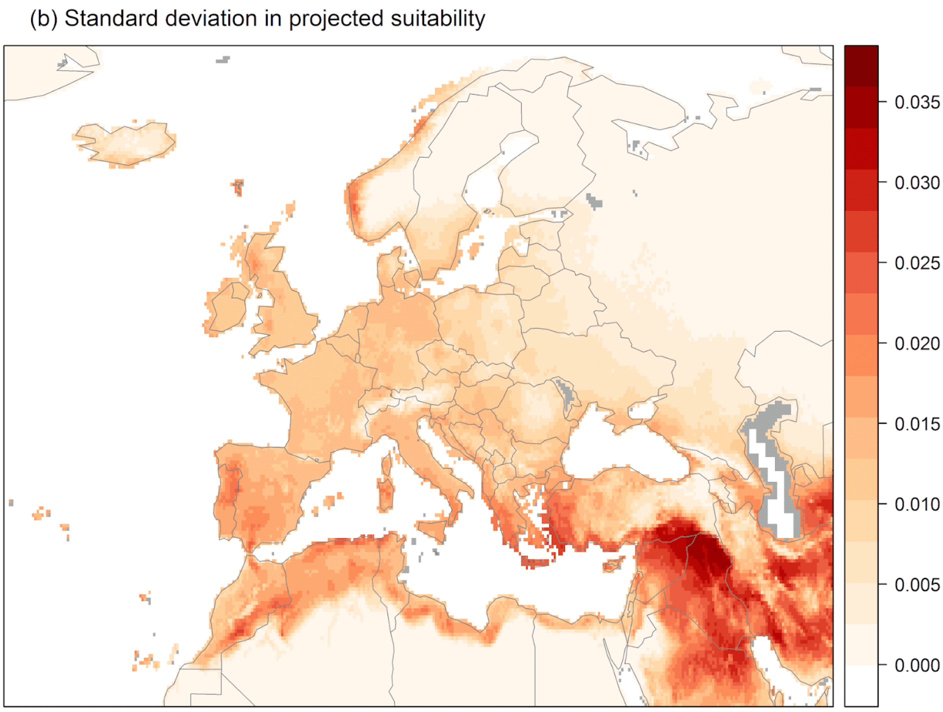


Figure 8. (a) Projected suitability for *Pycnonotus cafer* establishment in Europe and the Mediterranean region in the 2070s under climate change scenario RCP4.5, equivalent to Figure 5. Grey areas have missing data in a predictor layer. (b) Uncertainty in the ensemble projections, expressed as the among-algorithm standard deviation in predicted suitability, averaged across the 10 datasets.

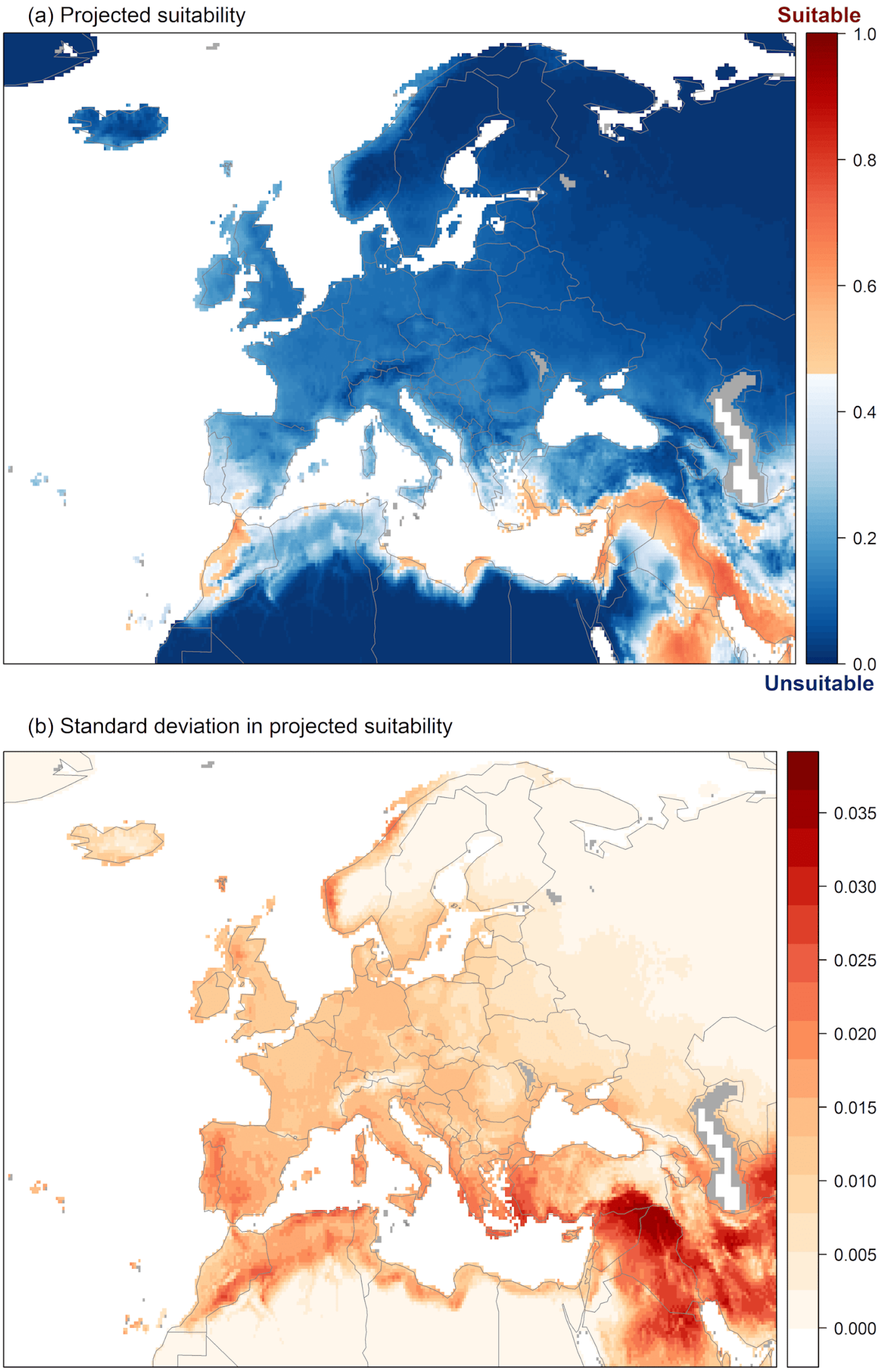
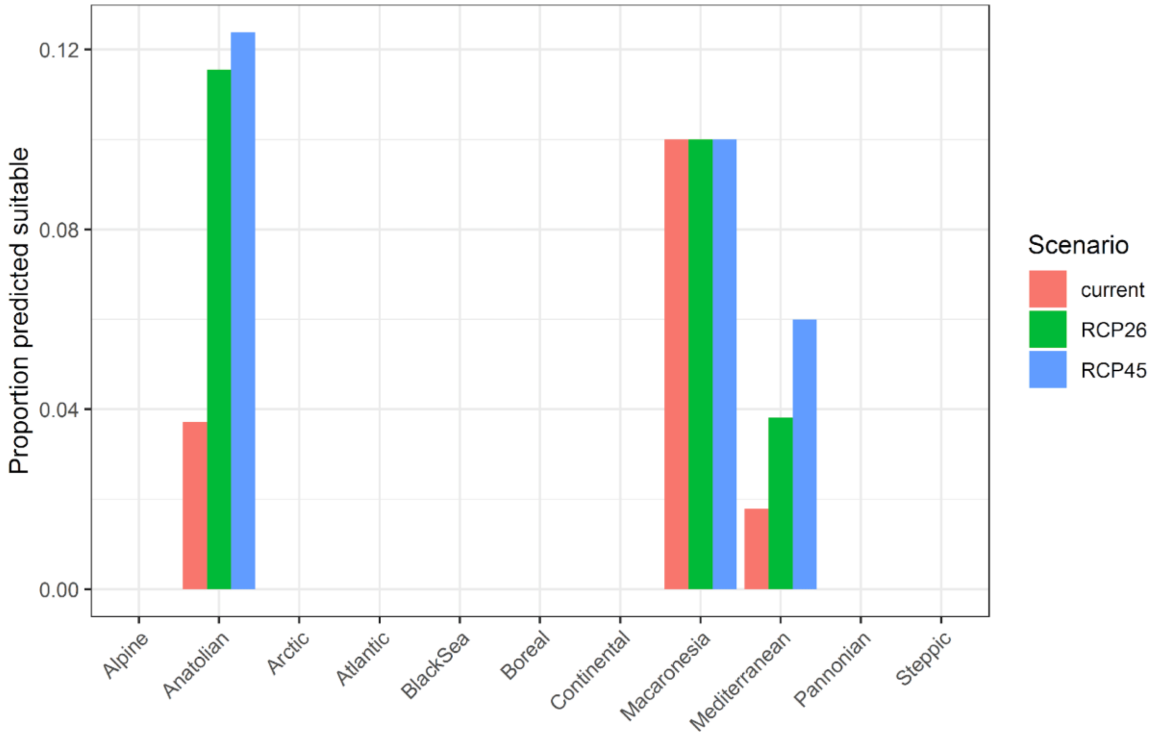


Figure 9. Variation in projected suitability for *Pycnonotus cafer* establishment among Biogeographical regions of Europe (https://www.eea.europa.eu/data-and-maps/data/biogeographical-regions-europe-3)). The bar plots show the proportion of grid cells in each region classified as suitable in the current climate and projected climate for the 2070s under two RCP emissions scenarios. The location of each region is also shown. The Arctic and Macaronesian biogeographical regions are not part of the study area, but are included for completeness.



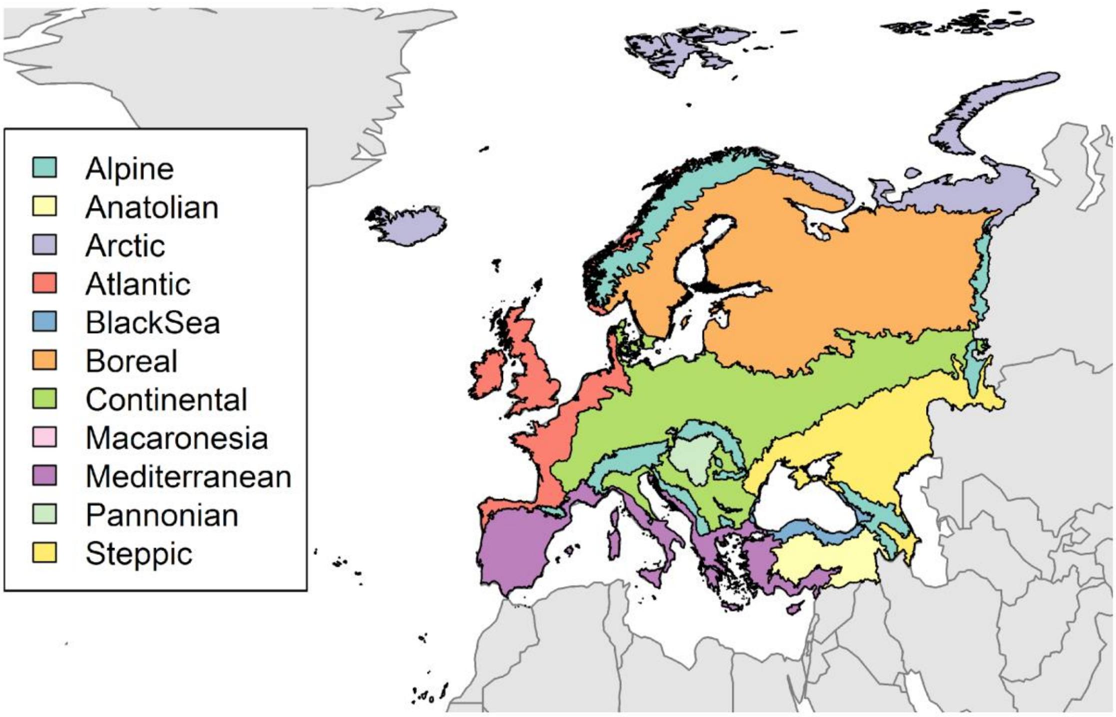
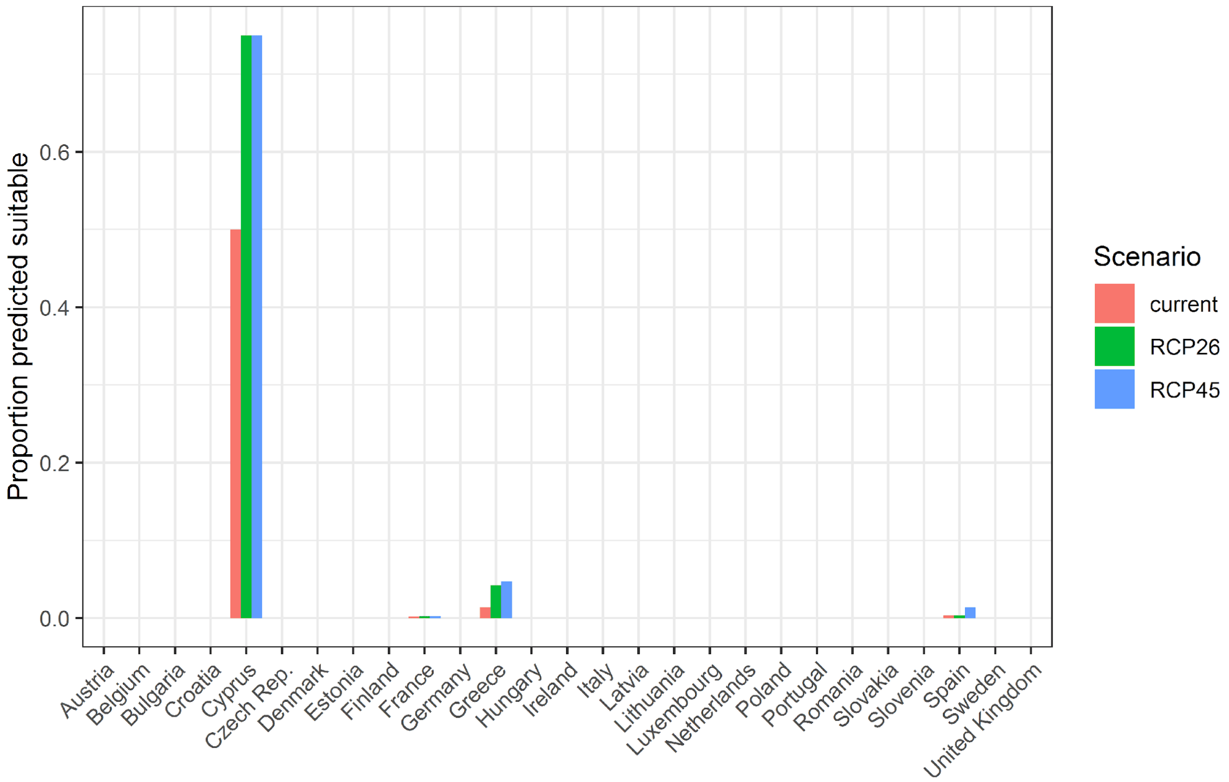


Figure 10. Variation in projected suitability for *Pycnonotus cafer* establishment among European Union countries and the United Kingdom. The bar plots show the proportion of grid cells in each country classified as suitable in the current climate and projected climate for the 2070s under two RCP emissions scenarios. Malta has been excluded because the Human Influence Index dataset lacks coverage for Malta.



Caveats to the modelling

To remove spatial recording biases, the selection of the background sample was weighted by the density of Aves records on the Global Biodiversity Information Facility (GBIF). While this is preferable to not accounting for recording bias at all, it may not provide the perfect measure of recording bias.

There was substantial variation among modelling algorithms in the partial response plots (Figure 3). In part this will reflect their different treatment of interactions among variables. Since partial plots are made with other variables held at their median, there may be values of a particular variable at which this does not provide a realistic combination of variables to predict from.

Other variables potentially affecting the distribution of the species, such as land cover were not included in the model.

References

Allouche O, Tsoar A, Kadmon R (2006) Assessing the accuracy of species distribution models: prevalence, kappa and the true skill statistic (TSS), *Journal of Applied Ecology*, 43, 1223-1232.

Chapman D, Pescott OL, Roy HE, Tanner R (2019) Improving species distribution models for invasive non-native species with biologically informed pseudo-absence selection. *Journal of Biogeography*, https://doi.org/10.1111/jbi.13555.

Cohen J (1960) A coefficient of agreement of nominal scales. *Educational and Psychological Measurement*, 20, 37-46.

Elith J, Kearney M, Phillips S (2010) The art of modelling range-shifting species. *Methods in Ecology and Evolution*, 1, 330-342.

Fielding AH, Bell JF (1997) A review of methods for the assessment of prediction errors in conservation presence/absence models. *Environmental Conservation*, 24, 38-49.

Hijmans RJ, Cameron SE, Parra JL, Jones PG, Jarvis A (2005) Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology*, 25: 1965-1978.

Iglewicz B, Hoaglin DC (1993) How to detect and handle outliers, Asq Press.

Manel S, Williams HC, Ormerod SJ (2001) Evaluating presence-absence models in ecology: the need to account for prevalence. *Journal of Applied Ecology*, 38, 921-931.

McPherson JM, Jetz W, Rogers DJ (2004) The effects of species' range sizes on the accuracy of distribution models: ecological phenomenon or statistical artefact? *Journal of Applied Ecology*, 41, 811-823.

Thuiller W, Lafourcade B, Engler R, Araújo MB (2009) BIOMOD-a platform for ensemble forecasting of species distributions. *Ecography*, 32, 369-373.

Thuiller W, Georges W, Engler R and Breiner F (2019). biomod2: Ensemble Platform for Species Distribution Modeling. R package version 3.3-7.1. https://CRAN.R-project.org/package=biomod2