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Critical Review

Focal Species Candidates for Pesticide Risk Assessment in European Rice Fields: A Review

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ABSTRACT

An assessment of potential risks of pesticides on wildlife is required during the process of product registration within Europe because of the importance of agricultural landscapes as wildlife habitats. Despite their peculiarity and their specific role as artificial wetlands, rice paddies are to date pooled with cereals in guidance documents on how to conduct risk assessments for birds and mammals in Europe. Hence, the focal species currently considered in risk assessments for rice paddies are those known from cereal fields and can therefore be expected to differ significantly from the species actually occurring in the wet environments of rice paddies. We present results of a comprehensive review on bird and mammal species regularly occurring in rice paddies during a time of potential pesticide exposure to identify appropriate focal species candidates for ecotoxicological pesticide risk assessment according to the European Food Safety Authority (EFSA). In addition, we present data on rice cultivation areas and agricultural practices in Europe to give background information supporting the species selection process. Our literature search identified a general scarcity of relevant data, particularly for mammals, which highlights the need for crop-specific focal species studies. However, our results clearly indicate that the relevant bird and mammal species in rice fields indeed differ strongly from the focal species used for the cereal risk assessment. They can thus be used as a baseline for more realistic wildlife risk assessments specific to rice and the development of a revised guidance document to bridge the gap for regulatory decision makers. *Integr Environ Assess Manag* 2018;14:537–551. © 2018 SETAC

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INTRODUCTION

Agricultural landscapes in general, and rice (*Oryza sativa*) fields in particular, play an increasing role as habitats for wildlife (Eisen Rupp et al. 2011; van der Weijden et al. 2010), especially in areas where natural habitats such as riverside wetlands, marshes, or wet meadows are absent or suffer from constant reduction and destruction (Longoni 2010). Within the agricultural landscape, rice fields or paddies are particularly noteworthy because corresponding standard agricultural practices include the temporary flooding of the field to control weeds and to protect rice plants from extreme temperatures and rapid temperature variations (Elphick 2010; Ferrero and Tinarelli 2008; Longoni 2010; MED-Rice 2003). Such flooded paddies represent temporary artificial wetlands (Elphick et al. 2010a; Ibáñez et al. 2010; Longoni 2010) and flooding is thus regarded as a key conservation value of rice field habitats due to the importance of wetlands for wildlife and the ongoing decrease in availability of natural wetlands (Elphick 2010; Sánchez-Guzmán et al. 2007). All over the world, including southern Europe, such rice field wetlands are used as stopover sites by millions of birds during migration (Elphick et al. 2010a; Ibáñez et al. 2010; Longoni 2010) or as wintering grounds (Mugica et al. 2006; Pernollet et al. 2015; Rendón et al. 2008). In addition, resident birds and mammals use them year-round as foraging habitat and for reproduction (Elphick et al. 2010a; Fasola and Cardarelli 2014; Longoni 2010; Toral and Figuerola 2010). However, as per normal agricultural practice, rice fields are regularly treated with pesticides, which may put wildlife at risk (EFSA 2009; Parsons et al. 2010).

The EU Regulation 1107/2009 directs the assessment of potential negative effects of pesticides on nontarget wildlife. More specifically, the current guidance document (GD) on risk assessment for birds and mammals (EFSA 2009) provides the general procedures to assess the risks to birds and mammals. In general, the risk assessment scheme follows a tiered theoretical approach starting with very general assessments based on very general assumptions with worst-case characteristics (e.g., imaginary indicator species), but, if need be, it proceeds with more specific assessments based on more realistic data (e.g., actually relevant true species; for an avian cereal scenario example, see Ludwigs et al. 2013). When an active substance or its associated products and uses fail a first-tier risk assessment, so-called refinement steps are used for higher tier risk assessments.

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Such refinements often include more detailed and realistic data on "focal species" that are specifically relevant for the corresponding crop and pesticide application scenario (for more details and specific crop-related focal species choices, see Dietzen et al. 2014).

A focal species is on the one hand defined as a species that regularly occurs in the target crop at the time when the plant protection product is applied. On the other hand, it should also be representative of all other species of the same foraging guild that may occur in the relevant crop at that time (EFSA 2009). A focal species is therefore not necessarily the species that is most often seen in the crop. Instead, to be considered representative, a focal species should have the highest potential exposure of all relevant (i.e., regularly occurring) species in its respective foraging guild (irrespective of its conservation status). Hence, factors such as foraging strata, food intake rate, diet composition, and body weight also need to be taken into account. Such focal species should be identified for each foraging guild. Despite these rather strict requirements for the determination of focal species for a particular crop group, rice is included in the crop group "cereals" in the current GD (EFSA 2009). It is further stated that the "risk assessment for a rice scenario is not included in this document because it is envisaged that it will be addressed in a separate guidance document" (EFSA 2009); however, such guidance is not available yet. The preliminary classification of rice as part of the cereal crop group does not consider that rice paddies represent a very different habitat compared to cereal fields and that the species composition and thus the relevant focal species probably differ drastically. A detailed assessment of the bird and mammal fauna of rice fields in relation to the EFSA focal species concept is currently missing, and a direct comparison with the focal species proposed for cereals is thus far not possible. The literature review presented here aims at closing this gap (for a similar case of addressing missing focal species data for nonagricultural grassland within the respective EFSA 2009 guidance, see Schabacker et al. 2014).

Here, we review the available literature to obtain detailed information on birds and mammals occurring in rice fields in southern Europe. To put these data into context, we additionally collected general information on European rice cultivation such as common agronomic practices and overall extent of cultivation. We further discuss the appropriateness of specific species and recommend avian and mammalian focal species candidates for pesticide risk assessments considering the above-mentioned prerequisites.

METHODS

We searched different literature sources for general information on rice cultivation areas in Europe and for specific information on birds and mammals occurring in rice paddies. More specifically, a literature survey was conducted in a stepwise manner by the following procedure: (1) We used standard references on European birds and mammals plus national distribution atlases to obtain general information on bird and mammal species occurring in European rice cultivation areas. We especially searched for data on habitat preferences of these species to identify potential focal species; (2) We searched the RIFCON GmbH library, which currently contains nearly 8000 scientific articles on birds and mammals, for relevant data; (3) We searched the electronic databases BIOSIS, Google, and Google Scholar for the keywords "rice", "birds", and "mammals" in English, Italian, German, Spanish, and French; (4) We searched the reference lists of obtained publications for additional relevant scientific articles in journals not included in the electronic databases; (5) We contacted several specialists and institutions working on birds and mammals in rice for additional information and publications. We evaluated the selected literature on the one hand to obtain information on rice cultivation in Europe and on the other hand to determine potential focal species candidates for wildlife risk assessment. Please note that we focused on countries that belong to the European Union (EU) to facilitate relation to the EU-specific pesticide risk assessment process according to EFSA.

Birds

The literature on birds was initially evaluated in relation to general occurrence of all recorded species in rice fields in southern Europe. The relevant literature was then further evaluated to get, if possible, an estimate of quantitative occurrence. While the evaluated data did not directly include specific "frequencies of occurrence" for individual species (a quantitative measure of presence within surveyed fields to determine focal species; for details, see Appendix M in EFSA 2009 or Dietzen et al. 2014), we estimated this parameter based on information given in the corresponding publication or data source and assigned all relevant species to categories of relative occurrence accordingly. For birds, the categories were (1) "species not recorded", (2) "species recorded", and (3) "species recorded with important numbers/frequency". It was additionally determined if a given species was recorded as nesting in rice fields. We then added information on the body weight of these species, as given in the literature.

Mammals

For mammals, relevant data were lacking. In particular, none of the evaluated studies used trapping, camera traps, or direct observations (neither at daylight nor with thermal image cameras) to identify mammal species in rice. We therefore mainly used descriptive information available from general mammal literature such as distribution atlases, field guides, and internet databases like the IUCN Red List of Threatened Species. We could obtain some additional data from biochemistry or zoonosis studies for which animals were sampled in rice paddies, albeit with very few details on exact trapping locations. Overall, most data came from publications describing mass outbreaks of mammals in rice fields. As less information was available for mammals than for birds, we used the following less-detailed categories of relative occurrence: (1) "species not recorded", (2) "species not recorded but occurs in respective country", and (3) "species recorded". In addition, we evaluated indirect evidence for the presence of mammal species in rice paddies derived from diet analyses of owls and heron nestlings.

Species lists

The collected data for birds and mammals were used to compile lists with potential focal species candidates. We subdivided the species lists in different diet guilds according to the EFSA (2009) risk assessment scheme to facilitate determination of the species most representative for all species of the same foraging guild that occur in rice paddies. For this, the main route of exposure to pesticides—dietary uptake via contaminated food—needs to be considered (EFSA 2009). In general, all foraging guilds with direct exposure to potentially contaminated food items should be considered. This includes insectivorous, herbivorous, granivorous, and omnivorous species. While carnivorous species are typically not directly addressed in wildlife risk assessments, piscivorous species are relevant for the assessment of potential secondary poisoning in birds and mammals (EFSA 2009).

Without considering further ecological parameters, the species with the lowest body weight from each foraging guild may in principle be assumed to be most at risk from exposure to residues of crop protection products on food items (EFSA 2009). This reasoning is based on the allometric relationship between metabolic rate and body weight, which leads to higher food intake rates per gram body weight in species with lower body weight (Nagy et al. 1999). Therefore, we sorted the compiled species lists by body weight for each of the relevant foraging guilds while additionally indicating the estimated degree of presence in rice fields (according to the occurrence categories listed above).

RICE CULTIVATION IN EUROPE

Rice producers

Rice cultivation in the EU covers more than 400 000 ha while accounting for less than 1% of the global rice production in 2016 (FAOSTAT 2017). Italy is the most important rice producer in Europe with more than 200 000 ha of rice paddies (FAOSTAT 2017; Figure 1). Italian rice cultivation is primarily based in the northwestern region of the Po Valley, where complex hydrogeological structures facilitate the flooding of the fields, and in the delta of the Po River (Longoni 2010). The main producing regions are Piemonte, Lombardia, Emilia-Romagna, and Veneto (MED-Rice 2003).

Spain is the second largest rice producer in Europe with more than 100 000 ha of rice paddies (FAOSTAT 2017; Figure 1). Extremadura and Andalucá represent the regions with the highest rice production. Other extensive cultivation areas exist in the Ebro delta and Albufera de València regions (MED-Rice 2003; Longoni 2010). The development and transfer of the Rice Integrated Crop Management system have increased the rice production in the recent past. In the Ebro delta about 65% (21 000 ha) of the total area is rice paddies; simultaneously, it represents the second most important bird area in Spain.

All other countries have much smaller production areas (if any) than Italy or Spain and are thus of less importance for rice production in the EU. Rice paddies cover about 30 000 ha in both Portugal and Greece (FAOSTAT 2017; Figure 1). The main cultivation areas in Portugal are in the Tejo, Sado, and Mondego valleys of central Portugal and in Greece in the Tessaloniki region, where the high salt contents of the deltaic environment do not permit the cultivation of other crops (Longoni 2010). Other growing regions in Greece are Serres, Imathia, Pieria, and Fthiotida (MED-Rice 2003).

In France, the total rice-growing area is around 15 000 ha (FAOSTAT 2017; Figure 1). Most rice cultivation occurs in the Rhône Delta (Camargue) where, similar to Greece, the high salt contents of the deltaic soils are not suitable for the cultivation of other crops (MED-Rice 2003; Longoni 2010). In addition, some minor cultivation areas are present in Bulgaria, Romania, and Hungary (FAOSTAT 2017; Figure 1).

Agronomic practices

In Europe, rice is grown mainly under irrigated, chemically intensive conditions, in highly mechanized medium to large farms. It is predominantly cultivated on fine-textured, poorly drained soils that are not appropriate for other crops, often in coastal areas with saline soils (Longoni 2010). Rice paddies are traditionally flooded before ("water seeding") or immediately after seeding (Ferrero and Tinarelli 2008; Longoni 2010; Ranghetti et al. 2016), which happens in April or May depending on the country and in relation to climate and water availability (Ferrero and Tinarelli 2008; MED-Rice 2003). Direct seeding by broadcasting is the common method of crop establishment. The water keeps the seeds at an optimal temperature until germination 20–30 days after sowing (Longoni 2010), while at the same time reducing weed emergence. During the growing period, fields remain flooded but water levels typically fluctuate (including temporary drainage), either on purpose to favor rice rooting and to facilitate agricultural practices such as pesticide and fertilizer application or due to changes in weather conditions (e.g., during dry periods; Ferrero and Tinarelli 2008; Longoni 2010; MED-Rice 2003). In August or September (depending on the country), fields are then typically drained completely to facilitate harvesting (Ferrero and Tinarelli 2008; MED-Rice 2003), which is often done 20–30 days later (Longoni 2010). The remaining rice stubble is commonly burned and/or buried afterwards (Longoni 2010).

In the most important European rice-growing areas in northern Italy, crop management has gradually changed during the last decade, with seeding under dry conditions becoming more common (Ranghetti et al. 2016). After dry seeding, fields are typically maintained mostly dry until approximately 1 month after germination and then either flooded continuously ("dry seeding with delayed flooding") or occasionally ("dry seeding with turned irrigation"; Ranghetti et al. 2016). However, dry seeding cultivation was still only used on around 30% of rice paddies in northern Italy in 2014 (Ranghetti et al. 2016), and flooding paddies

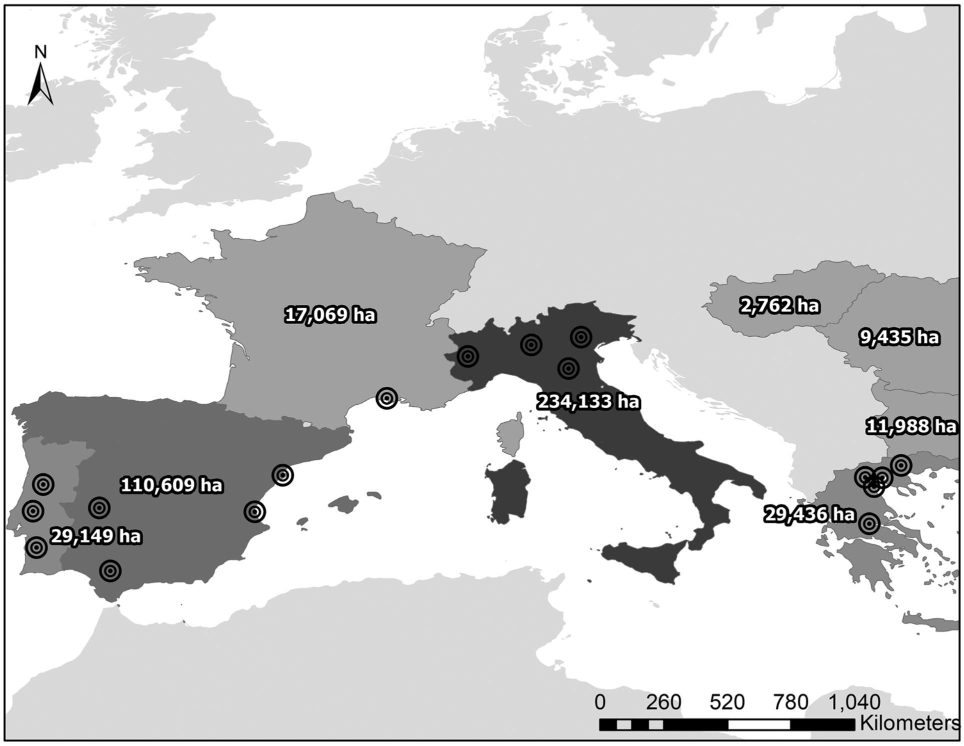

Figure 1. Rice producers in the EU and main cultivation areas (depicted by circles). Given is the total rice cultivation area per country in 2016, based on FAOSTAT (2017). Relevant countries are shaded accordingly from light (small crop area) to dark (large crop area).

already before or shortly after sowing as described earlier remains the dominant method in Europe.

In rare cases, rice paddies can also be reflooded during the noncropping season (autumn and winter), e.g., in areas with certain hydrological conditions or if required by conservation contracts (for paddies located within nature conservation areas). However, keeping rice paddies flooded during the noncropping season can be costly for the farmer (while not being necessary per se) and is thus not very common in Europe (Elphick et al. 2010a; Longoni 2010; Lourenco and Piersma 2009).

Agronomic practices in relation to pest management are mostly targeting weeds as the most important pest organisms affecting rice cultivation in Europe (Ferrero and Tinarelli 2008). Major weeds include *Echinochloa* spp., *Heteranthera* spp., and various weedy rice biotypes. Diseases, mostly caused by parasitic fungi, are common as well, but heavy yield losses due to diseases are much less frequent than those caused by the presence of weeds. Invertebrate pest species are also relevant but are typically not considered a major threat (Ferrero and Tinarelli 2008). Consequently, while fungicides and insecticides are also used regularly in some areas (Longoni 2010), herbicides are by far the most commonly applied pesticides in European rice cultivations, and herbicide applications are usually focused on the earlier stages of rice plant development in spring and early summer (Ferrero and Tinarelli 2008; MED-Rice 2003).

BIRDS AND MAMMALS IN EUROPEAN RICE FIELDS

Birds

A total of 121 bird species from 13 different orders were recorded at least occasionally in rice fields in Europe (Supplemental Table S1). Most observed species belong to the group of waders and gulls (50 species), followed by passerines (25 species), ducks and geese (15 species), and herons and storks (12 species). These species represent carnivorous, granivorous, herbivorous, insectivorous, omnivorous, and piscivorous (fish-amphibian specialists) foraging guilds.

Many recorded bird species are associated with shallow water and use rice paddies mainly as foraging habitats (Elphick 2010). In addition, rice fields serve as stopover sites for many bird species during migration, which results in maximum species diversity and abundance in early spring and late autumn. However, particularly autumn migration does not usually coincide with the rice cultivation stages relevant for pesticide risk assessment (see '*Agronomic practices*' section). Only a small percentage (15%, 18 species) of all recorded bird species actually breed in, or directly adjacent, to rice paddies. Nevertheless, for those species rice paddies can be a major breeding habitat, and the individuals associated with rice can amount to a substantial part of the overall population (at least on a regional scale). For instance, up to 76% of the local heron and egret breeding populations in northwestern Italy breed in or at rice fields (Fasola and Brangi 2010), and changes in rice water management practices have led to a clear overall decrease of those breeding populations in recent years (Fasola and Cardarelli 2014).

The complete species list in Supplemental Table S1 includes many species that were only qualitatively and occasionally recorded in, or at, rice fields in the evaluated literature. This lack of regular observations and quantitative data indicates that those species do not occur in rice paddies in relevant numbers or frequency. The following evaluation per diet guild was thus focused on all species that were quantitatively recorded on the basis of a subset of publications from Spain and France that provided such data (see Tables 1 to 2). In addition, the evaluation was based on the data provided for spring and summer to cover the main period for flooding and pesticide application.

Carnivorous and granivorous birds. Only 2 carnivorous (short-eared owl and marsh harrier) and 2 granivorous species (linnet and goldfinch) were mentioned to occur occasionally in, or at, rice fields (Supplemental Table S1). Therefore, the available data suggest that rice fields are only of minor importance for carnivorous and granivorous birds in Europe, and a separate risk assessment thus seems unnecessary.

Herbivorous birds. Several species of dabbling ducks and the greylag goose were observed in European rice fields (Table 1). According to EFSA (2009), a large herbivorous bird (e.g., goose) should be considered for the rice risk assessment based on cereal data. However, although greylag geese are regularly recorded in rice fields (e.g., Longoni 2010; Sánchez-Guzmán et al. 2007; Toral and Figuerola 2010), several much smaller species of ducks were found to occur more abundantly in the present review. The Eurasian teal has the lowest average body weight and is potentially regularly present in rice fields. However, Eurasian teals have not been recorded breeding and seem to utilize rice paddies primarily outside the rice cultivation period, during migration and in winter between September and April (Dubois et al. 2000; Juana and Garcia 2015).

In contrast, mallards use rice fields year-round in large numbers, particularly also throughout their main breeding season in spring and summer (April–July). Among all recorded species, mallards had by far the highest occurrence rates across regions and were also observed breeding directly in rice fields, which further indicates that they occur in rice paddies during application of pesticides and possibly have a higher risk for reproductive effects. All other species with lower body weights than mallards were less common; they were recorded primarily during migration (i.e., mainly outside the rice cultivation and crop maintenance period) and did not nest in rice paddies. Additionally, in laboratory studies, which are the basis for avian risk assessments, the mallard is one of the common model species used for standard toxicity testing of active substances in pesticides (EFSA 2009); using the mallard would thus reduce the uncertainty associated with corresponding toxicity endpoint in the risk assessment. Hence, the mallard can be considered as the most representative focal species candidate for the herbivorous bird guild, particularly for reproductive risk assessments.

Insectivorous birds. A large variety of different species of waders, gulls, and terns was recorded quantitatively in European rice fields (Table 2). Several species occurred in all evaluated rice-growing regions during the summer (flooded) period. However, most of the recorded insectivorous birds are long-distance migrants, using rice fields only as stopover sites during their migration, but black-winged stilt, northern lapwing, black-tailed godwit, cattle egret, and glossy ibis were also found nesting in rice paddies.

In principle, the little stint may be seen as the most representative focal species candidate if only evaluating body weight. Alternatively, the wood sandpiper could be seen as more reasonable, because it occurred more frequently and to some extent also at higher abundances. However, both species are migratory and therefore not exposed to plant protection chemicals for extended periods. Some exposure might occur during the late spring/early summer migration or during the onset of autumn migration in July, but their main and peak migration is before and after rice cultivation takes place (Dubois et al. 2000; Juana and Garcia 2015).

In contrast, the black-winged stilt (lower body weight) and northern lapwing (higher frequency of occurrence/presence category) utilize rice paddies during their main breeding seasons in spring and summer (April–June), while still having a comparatively low body weight compared to other breeding species; they can thus be considered as the most representative focal species candidates. The northern lapwing is also proposed as spring/summer focal species for rice scenarios in Italy by Auteri et al. (2006).

Omnivorous birds. Several species of diving ducks, gulls, rails, and crane-like species were recorded quantitatively in European rice fields (Table 1). Among those, black-headed gulls had the highest occurrence rates across regions and were also observed breeding in rice fields. Two other recorded species, the Mediterranean gull (not recorded breeding in rice paddies) and the common moorhen, have slightly lower body weights than the black-headed gull, but both occurred less frequently and in lower numbers. Hence, following the criteria defined in EFSA (2009), the black-headed gull is the most representative focal species candidate because of its low body weight and its high frequency of occurrence. This species is potentially exposed to plant protection chemicals in rice paddies mainly during the rice cultivation period and is likely present in high abundances and in all regions during all periods.

Piscivorous birds (secondary poisoning). Of the piscivorous birds (including fish-amphibian specialists), mainly herons, egrets, and storks occurred in European rice fields (Table 1). Among those, little bittern and squacco heron both were

Table 1. Herbivorous, omnivorous, and piscivorous bird species recorded quantitatively in rice fields of southern Europe during spring and summer (main flooding period)

Species	Body weight (g)[a]	Toral and Figuerola (2010) Spain	Sánchez-Guzmán et al. (2007) Spain	Tourenq et al. (2003) France[b]
Herbivorous birds				
Eurasian teal *Anas crecca*	291.0	+	++	–
Garganey *Anas querquedula*	310.0	+	–	–
Marbled duck *Marmaronetta angustirostris*	477.0	++	–	–
Northern shoveler *Anas clypeata*	590.0	++	++	–
Eurasian wigeon *Anas penelope*	724.0	+	+	–
Gadwall *Anas strepera*	866.0	+	+	–
Northern pintail *Anas acuta*	887.0	+	+	–
Mallard *Anas platyrhynchos*	**1082.0**	++	++	++
Red-crested pochard *Netta rufina*	**1118.0**	+	–	–
Greylag goose *Anser anser*	3108.0	+	+	–
Omnivorous birds				
Mediterranean gull *Larus melanocephalus*	256.0	–	–	+
Common moorhen *Gallinula chloropus*	**271.0**	+	+	+
Black-headed gull *Larus ridibundus*	**284.0**	++	++	++
Ferruginous duck *Aythya nyroca*	574.0	+	–	–
White-headed duck *Oxyura leucocephala*	593.0	+	–	–
Tufted duck *Aythya fuligula*	680.0	+	–	–
Purple gallinule *Porphyrio porphyrio*	724.0	++	–	–
Lesser black-backed gull *Larus fuscus*	755.0	+	+	+
Eurasian coot *Fulica atra*	**770.0**	++	++	–
Common pochard *Aythya ferina*	823.0	+	–	–
Crested coot *Fulica cristata*	826.0	+	–	–
Yellow-legged gull *Larus michahellis*	1033.0	++	–	++
Common crane *Grus grus*	5500.0	+	++	–
Piscivorous birds				
Little bittern *Ixobrychus minutus*	118.0	++	+	+
Squacco heron *Ardeola ralloides*	**287.0**	++	–	+
Little egret *Egretta garzetta*	**312.0**	++	+	+
Black-crowned night heron *Nycticorax nycticorax*	**810.0**	+	–	+
Great egret *Ardea alba*	**812.0**	+	–	+
Purple heron *Ardea purpurea*	**1019.0**	++	–	+
Osprey *Pandion haliaetus*	1403.0	–	–	–
Grey heron *Ardea cinerea*	**1443.0**	++	+	+

(*Continued*)

Table 1. (*Continued*)

Species	Body weight (g)[a]	Toral and Figuerola (2010) Spain	Sánchez-Guzmán et al. (2007) Spain	Tourenq et al. (2003) France[b]
Great cormorant *Phalacrocorax carbo*	1936.0	++	–	–
Black stork *Ciconia nigra*	2926.0	–	–	–
White stork *Ciconia ciconia*	3325.0	++	+	–

Bold lines indicate species found nesting in rice paddies.
– Species not recorded.
+ Species recorded.
++ Species recorded with important numbers and frequency.
[a] Mean body weight according to Dunning (2008).
[b] Data available only for the period from April to June.

observed regularly, not only on migration, and the latter was also recorded breeding in rice paddies. Both species have low body weights compared to other species of this diet guild. According to the criteria defined in EFSA (2009), the little bittern may be seen as the most representative focal species candidate because of its low body weight and the relatively high frequency of occurrence. It is potentially exposed to plant protection chemicals in rice paddies throughout spring and summer, but it does not seem to use rice fields in autumn.

The fish-eating scenario (secondary poisoning) is particularly important for flooded rice fields because these attract large numbers of fish- and amphibian-eating specialists, i.e., herons, storks, and osprey. While no specific focal species is stated for this scenario in the GD, a "1000-g bird" is recommended as a default assumption for the risk assessment for fish-eating birds independent of the crop (EFSA 2009). However, as described above, the available data suggest that species with considerably lower body weight such as the little bittern may be more suitable focal species in the case of rice. In addition, several other small piscivorous species (little egret, squacco heron, black-crowned night heron) can be much more common than the little bittern in specific areas of use and may be selected for risk assessment on a case-by-case basis.

Mammals

Mammals observed in rice paddies. In total, we found information about 10 mammal species directly observed in rice paddies in Europe (Table 3). Because their occurrences differed strongly between regions, we present the results for each of the rice-growing countries separately.

For France, no direct observations of mammals in rice fields were publicly available. For Spain, the brown rat and the southern water vole are known to inhabit rice paddies (Blanco 1998; Palomo and Gisbert 2002). Furthermore, Algerian mice were captured close to rice fields in Spain, and finally, the American mink—a primarily carnivorous, invasive species—was observed in rice paddies (Garcá-Berthou et al. 2007). For Portugal, the brown rat as a common species (Mitchell-Jones et al. 1999) is recorded as a cause of damage in rice paddies (Bäumler et al. 1984). For Italy, the harvest mouse was observed in rice fields (Palomo and Gisbert 2002). For Greece, the wood mouse and yellow-necked mouse were captured in rice fields near Serres and Thesaloniki (Antoniadis et al. 1987), and mass outbreaks of European water voles are reported from the Republic of Macedonia (Dundjerski 1988). In addition, Klimentova et al. (2011) report larger mammals like Eurasian otter and coypu for rice paddies in Bulgaria. No records were available of insectivorous species such as shrews in the evaluated literature.

Taken together, several small mammal species could be considered representative focal species candidates for rice but only on the basis of a very limited data set. The omnivorous brown rat is the most frequently described species in rice-growing regions considering all available literature. The much smaller harvest mouse may also inhabit rice fields, as found in northern Italy (Palomo and Gisbert 2002) and in some other regions (e.g., Russia; Trout 1978). However, the harvest mouse predominately occurs in central and northern Europe and is fully absent from some of the most important rice cultivation regions in Europe (e.g., southern Spain, Portugal). Based on the available data, it is therefore not considered an appropriate focal species candidate for the entire southern registration zone according to EFSA (2009). In contrast, the brown rat is distributed all over southern Europe (i.e., all rice cultivation areas in Europe), although there is, as for all mammal species, only limited information for direct associations of the brown rat with rice fields (Bäumler et al. 1984; Blanco 1998; Palomo and Gisbert 2002).

Considering solid trapping data from rice fields in the Republic of Macedonia, the only primarily herbivorous mammal species from which mass outbreaks in rice fields have been recorded in southeastern Europe was the European water vole (Dundjerski 1988). Another water-associated herbivorous species, the invasive muskrat (*Ondatra zibethicus*), can generally be found in France, Italy, and Bulgaria (Mitchell-Jones et al. 1999). In the United States, where it natively occurs, muskrats may cause substantial damages in rice paddies (New York State Department of Environmental Conservation 2004). However, we did not find any relevant information on the use of rice paddies by muskrats in Europe (thus, not included in Table 3). Although

Table 2. Mainly insectivorous bird species recorded quantitatively in rice fields of southern Europe during spring and summer (main flooding period)

Species	Body weight (g)[a]	Toral and Figuerola (2010) Spain	Sánchez-Guzmán et al. (2007) Spain	Tourenq et al. (2003) France[b]
Little stint *Calidris minuta*	21.1	+	+	–
Little ringed plover *Charadrius dubius*	38.7	+	+	–
Kentish plover *Charadrius alexandrinus*	42.3	++	–	+
Dunlin *Calidris alpina*	44.2	++	++	–
Jacksnipe *Lymnocryptes minimus*	46.7	+	–	–
Common sandpiper *Actitis hypoleucos*	48.0	+	+	+
Wood sandpiper *Tringa glareola*	53.0	++	+	++
Curlew sandpiper *Calidris ferruginea*	56.6	++	–	–
Sanderling *Calidris alba*	57.0	+	–	–
Little tern *Sternula albifrons*	57.0	++	+	–
Ringed plover *Charadrius hiaticula*	63.3	++	+	–
Black tern *Chlidonias niger*	65.3	++	+	+
Green sandpiper *Tringa ochropus*	71.4	++	+	+
Whiskered tern *Chlidonias hybridus*	77.8	++	+	+
Collared pratincole *Glareola pratincola*	84.9	++	+	–
Common snipe *Gallinago gallinago*	97.0	+	++	–
Water rail *Rallus aquaticus*	98.0	–	–	–
Ruff *Philomachus pugnax*	102.0	++	+	+
Little gull *Hydrocoloeus minutus*	118.0	+	–	–
Common redshank *Tringa totanus*	129.0	++	+	++
Little grebe *Tachybaptus ruficollis*	130.0	+	–	–
Ruddy turnstone *Arenaria interpres*	134.0	+	–	–
Red knot *Calidris canutus*	136.0	++	–	–
Spotted redshank *Tringa erythropus*	158.0	+	+	+
Black-winged stilt *Himantopus himantopus*	**161.0**	++	++	–
Common greenshank *Tringa nebularia*	187.0	++	+	++
Northern lapwing *Vanellus vanellus*	**211.0**	++	++	+
Golden plover *Pluvialis apricaria*	214.0	+	+	–
Gull-billed tern *Gelochelidon nilotica*	233.0	++	+	++
Grey plover *Pluvialis squatarola*	250.0	++	+	–
Black-tailed godwit Limosa limosa	**252.0**	++	++	–
Bar-tailed godwit *Limosa lapponica*	276.0	+	–	–
Pied avocet *Recurvirostra avosetta*	304.0	++	+	–
Whimbrel *Numenius phaeopus*	355.0	–	–	+
Cattle egret *Bubulcus ibis*	**360.0**	++	++	++
Black-necked grebe *Podiceps nigricollis*	374.0	+	–	–
Stone curlew *Burhinus oedicnemus*	459.0	+	–	–

(*Continued*)

Table 2. (*Continued*)

Species	Body weight (g)[a]	Toral and Figuerola (2010) Spain	Sánchez-Guzmán et al. (2007) Spain	Tourenq et al. (2003) France[b]
Glossy ibis *Plegadis falcinellus*	**605.0**	++	–	–
Great crested grebe *Podiceps cristatus*	686.0	+	–	–
Eurasian curlew *Numenius arquata*	742.0	+	+	+
Common shelduck *Tadorna tadorna*	1043.0	+	–	++
Eurasian spoonbill *Platalea leucorodia*	1868.0	++	–	–
Greater flamingo *Phoenicopterus roseus*	2530.0	+	–	++

Bold lines indicate species found nesting in rice paddies.
– Species not recorded.
+ Species recorded.
++ Species recorded with important numbers and frequency.
[a] Mean body weight according to Dunning (2008).
[b] Data available only for the period from April to June.

the European water vole does not occur in southern Spain and Portugal, where the southern water vole is common (Mitchell-Jones et al. 1999), its comparatively low body weight makes it a reasonable herbivorous focal species candidate based on the available data.

As described above, the brown rat is proposed as the appropriate omnivorous focal species due to its wide distribution in the south of Europe and the strong indications of its regular occurrence in rice fields. The brown rat may also be considered a general focal species covering different dietary exposure routes. Indeed, due to its often opportunistic diet, it could in principle be considered representative for most of the relevant foraging guilds, i.e., omnivore, herbivore, and insectivore, also considering that currently no data on insectivorous species in European rice fields are available. In addition, the brown rat is very closely related to the animals (usually laboratory rats) tested in registration-relevant toxicological acute and long-term studies needed to define the endpoints considered in the risk assessment according to EFSA (2009), thus reducing the uncertainty associated with the corresponding endpoint.

The only primarily fish-eating (piscivorous) species is the Eurasian otter, which was observed in rice paddies in Bulgaria. This species is therefore the only candidate for secondary poisoning scenarios (or bioaccumulation assessments) that can be derived from the available literature.

Mammals in the diet of birds foraging in rice paddies. Nineteen different mammal species were recorded as prey items of owls and heron nestlings in rice-growing areas in Greece, Italy, and Spain, providing indirect evidence for potential occurrence of those species in rice paddies (see Table 4). Based on these data, several small mammal species (mice, voles, and shrews) could be considered focal species candidates for Italy. In Greece, only water vole, common vole, and *Rattus* sp. were identified in the diet of night heron nestlings, while in Spain only the brown rat was found in the diet of purple heron nestlings.

However, for data obtained from the diet of birds it must be considered that in rice-growing regions other crops are also grown and bordering habitats other than rice are likewise hunting grounds for these bird species. The low number of carnivorous bird species recorded in rice fields based on the literature review (Supplemental Table S1) indeed indicates that rice paddies (particularly flooded ones) may not represent a preferred foraging habitat for birds feeding on small mammals. It is thus unknown whether the foraging birds captured the respective prey within rice paddies or in the adjacent habitats available at the study sites such as other crops (e.g., maize and wheat) or small deciduous woods, marshes, and rivers (Gotta and Pigozzi 1997; Fasola et al. 1981). Therefore, the indirect observations of mammals via the bird diet shown in Table 4 may be regarded as a list of possible focal species (i.e., "information") but not as list of "focal species" for rice according to the GD (EFSA 2009).

Summary of proposed focal species and example risk assessment

The proposed focal bird and mammal species for the different diet guilds, based on the available data as discussed above, are summarized in Table 5. In addition, Table 5 provides general information relevant for conducting the respective risk assessments for rice (body weight, diet composition, food intake rate per body weight) for each of the determined focal species candidates. We calculated the food intake rate per body weight (FIR/bw) according to the guideline provided in EFSA (2009). To put this data into context, a brief example risk assessment for birds and mammals is presented below for a hypothetical artificial pesticide proposed for use in rice fields. Assuming the imaginary pesticide is applied in earlier crop

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Table 3. Small mammal species observed in or close to rice paddies in southern Europe

Species	Diet guild	Body weight (g)	France	Spain	Portugal	Italy	Bulgaria	Greece
European water vole *Arvicola amphibius*	herbivorous	150.0[a]	o	o	–	o	o	+[g]
Southern water vole *Arvicola sapidus*	herbivorous	201.0[a]	o	+	o	–	–	–
Coypu *Myocaster coypus*	herbivorous	5400[a]	o	–	–	o	+	o
Harvest mouse *Micromys minutus*	omnivorous	8.0[b]	o	o[f]	–	+[f]	o	o
Algerian mouse *Mus spretus*	omnivorous	12.0–21.0[c]	o	+	o	–	–	–
Wood mouse *Apodemus sylvaticus*	omnivorous	21.7[d]	o	o	o	o	o	+
Yellow-necked mouse *Apodemus flavicollis*	omnivorous	35.4[b]	o	o	–	o	o	+
Brown rat *Rattus norvegicus*	omnivorous	290.0[d]	o	+	+	o	o	o
American mink *Neovison vison*	carnivorous	male: 1266 female: 737[e]	o	+	o	o	–	–
Eurasian otter *Lutra lutra*	piscivorous	6501[e]	o	o	o	o	+	o

– Species not recorded.
o Species not recorded but occurs in respective country.
+ Species recorded.
[a] Body weight according to Niethammer and Krapp (1982).
[b] Body weight according to Niethammer (1978).
[c] Body weight according to Palomo and Gisbert (2002).
[d] Body weight according to the GD "Risk Assessment for Bird and Mammals" (EFSA 2009).
[e] Body weight according to Stubbe and Krapp (1993).
[f] The harvest mouse is only distributed in the north of Spain and Italy (Mitchell-Jones et al. 1999).
[g] Water vole outbreaks in rice reported by the Republic of Macedonia bordering to the north of Greece.

growth stages from BBCH ("Biologische Bundesanstalt, Bundessortenamt und Chemische Industrie") 10 to 29, the following generic focal species for cereals (corresponding representative species given in brackets) would need to be considered applicable following Annex I of the current GD (EFSA 2009):

- Large herbivorous bird "goose" (pink-footed goose)
- Small omnivorous bird "lark" (woodlark)
- Small insectivorous mammal "shrew" (common shrew)
- Large herbivorous mammal "lagomorph" (rabbit)
- Small omnivorous mammal "mouse" (wood mouse)

In contrast, the following generic bird and mammal focal species could be derived from the rice-specific focal species candidates presented in Table 5:

- Medium insectivorous bird "wader" (black-winged stilt or northern lapwing)
- Large herbivorous bird "duck" (mallard)
- Medium omnivorous bird "gull" (black-headed gull)
- Small herbivorous mammal "vole" (European water vole)
- Medium omnivorous mammal "rat" (brown rat)

To keep the risk assessment concise, piscivorous species (secondary poisoning) were not considered here. In addition, only the acute risk via dietary exposure was assessed (no reproductive assessment). Acute toxicity-exposure-ratio (TER) values were calculated according to EFSA (2009) with the following formula:

$$\text{TER} = \text{acute toxicity endpoint}/\text{application rate} \times \text{shortcut value}$$

For the example calculation, the application rate was set to 1 kg/ha and the acute toxicity endpoints assumed to be 300 and 100 mg/kg body weight for birds and mammals, respectively. The shortcut values for the EFSA generic focal species were taken from Appendix A of the GD (EFSA 2009). Please note that it is not fully clear in each case how these shortcut values were originally derived by EFSA. As a preliminary, conservative approach, the shortcut values for the proposed generic focal species for rice were calculated based on their food intake rate (FIR) in g fresh weight/day per body weight in g (Table 5) and the 90th percentile residue unit dose (RUD) in mg/kg (Appendix A of EFSA 2009) of their respective diet composition (Table 5; 100% foliar insects for insectivorous birds as a worst-case approach), assuming no interception or other possible causes of lower residue uptake:

$$\text{shortcut value} = \text{FIR}/\text{bw} \times 90^{th} \text{ percentile RUD}$$

The following resulting acute TER values (only worst-case value shown for each scenario) are based on the EFSA recommendations for cereals (left side of slash) and based on the proposed focal species for rice (right side of slash): insectivorous bird —/21.3; herbivorous bird 9.8/7.3; omnivorous bird 12.5/40.6; insectivorous mammal 13.2/—; herbivorous mammal 2.4/1.2; omnivorous mammal

Table 4. Small mammal species found in the diet of mammal-eating birds foraging in rice-growing areas in southern Europe[a]

	Gotta and Pigozzi (1997) Italy[b]		Fasola et al. (1981) Italy[c]	Kazantzidis and Goutner (2005) Greece[d]	Montesinos et al. (2008) Spain[e]
Species	Barn owl	Little owl	Night heron	Night heron	Purple heron
Common shrew *Sorex araneus*	62	1	2	–	–
Western house mouse *Mus domesticus*	14	7	1	–	–
Yellow-necked mouse *Apodemus flavicollis*	–	–	1	–	–
Apodemus sp.	83	62	1	–	–
Harvest mouse *Micromys minutus*	270	78	4	–	–
Savi's pine vole *Microtus savii*	81	12	1	–	–
European water vole *Arvicola amphibius*	107	6	3	1	–
Common vole *Mircotus arvalis*	–	–	–	2	–
Rattus sp.	48	2	–	2	–
Brown rat *Rattus norvegicus*	95	5	–	–	1
Common mole *Talpa europaea*	3	–	–	–	–
Blind mole *Talpa caeca*	1	–	–	–	–
Pygmy shrew *Sorex minutus*	4	–	–	–	–
Water shrew *Neomys fodiens*	1	–	–	–	–
Miller's water shrew *Neomys anomalus*	1	1	–	–	–
Common dormouse *Muscardinus avellanarius*	10	–	–	–	–
Alpine pine vole *Microtus multiplex*	26	2	–	–	–
Lesser white-toothed shrew *Crocidura suaveolens*	12	7	–	–	–
Bi-coloured white-toothed shrew *Crocidura leucodon*	59	4	–	–	–
Bank vole *Clethrionomys glareolus*	2	–	–	–	–
Wood mouse *Apodemus sylvaticus*	193	102	–	–	–

[a] Please note that these numbers are estimated based on animal remains, cannot be assigned to adults or juveniles, and are not necessarily related to resident animals in rice fields.
[b] Data available for the whole year.
[c] Data available only for May to August.
[d] Data available only for April to July.
[e] Data available only for May to July.

5.8/11.9. TER values above 10 pass the official trigger value and indicate a safe use. TER values below the trigger could be further refined, for instance with ecological data for the suggested rice-specific focal species where appropriate (not shown). As shown in this example, the quantitative outcome, and thus also potentially the regulatory outcome, differs when considering the information of this review compared to the EFSA default assumptions, and differential outcomes would also be expected when assuming other uses, BBCH stages, application rates, or toxicity values.

DISCUSSION

Rice paddies are ecologically important as they temporarily offer wetland-like habitats to many animals, especially birds, during all seasons (Elphick et al. 2010b). Studies have demonstrated that flooded rice fields are similarly attractive to migrating waterbirds (i.e., shorebirds, ducks) and to coastal wetland habitats (e.g., Mugica et al. 2006). The current bird and mammal guideline (EFSA 2009) considers rice paddies as cereal fields. However, when species-specific ecological data are applied during higher tier refinement steps of the risk assessment (for an avian cereal example, see

Table 5. Proposed focal bird and mammal species and parameters relevant for the risk assessment of rice scenarios in southern Europe

Diet guild	Species	Relevant period	Body weight (g)	Diet composition[a]	FIR[b]	FIR/body weight
Birds						
Herbivorous	Mallard	year-round	1082.0	100% rice shoots	434.20	0.40
Insectivorous	Black-winged stilt	April–June	161.0	100% arthropods	42.30	0.26
Insectivorous	Northern lapwing	April–June	211.0	100% arthropods	50.69	0.24
Omnivorous	Black-headed gull	year-round	284.0	25% crop leaves 25% weed seeds 50% arthropods	45.04	0.16
Piscivorous	Little bittern	spring–summer	118.0	100% fish	38.00	0.32
Mammals						
Herbivorous	European water vole	year-round	150.0	100% rice shoots	120.06	0.80
Omnivorous	Brown rat	year-round	290.0	25% weeds 50% weed seeds 25% arthropods	36.98	0.13
Piscivorous	Eurasian otter	year-round	6501	100% fish	722.08	0.11

FIR = food intake rate in g fresh weight per day.
[a] Diet composition adopted from cereal scenarios of Appendix A of the GD (EFSA 2009).
[b] For the calculation of the FIR, the assimilation efficiency was taken from the Appendix L of the GD (EFSA 2009).

Ludwigs et al. 2013), the differences to cereal fields should become evident. Unfortunately, field studies presenting crop- and species-specific data are currently lacking for rice fields, as are studies determining potential focal species candidates (according to EFSA 2009; Appendix M), although publicly available for nearly all other crops or crop groups (Dietzen et al. 2014; Schabacker et al. 2014). The present literature review identifies focal bird and mammal species candidates for rice scenario risk assessments. In particular, we could gather appropriate data on bird species that use rice fields during rice cultivation and potential pesticide application periods, but such data were rather scarce for mammals. We could identify focal bird species candidates for each of the important foraging guilds, resulting in general suggestions for southern European countries, and also suggest several potential focal mammal species.

According to the GD (EFSA 2009), a pesticide risk assessment for birds in rice (assuming application during all possible crop growth stages) should consider a small insectivorous "passerine", a large herbivorous "goose", a small omnivorous "lark" and a small granivorous/insectivorous "bunting", based on the requirements for cereals as described earlier. In the case of small insectivorous ("passerine") and small omnivorous birds ("lark", "bunting") these taxa were only reported once in rice fields (all in one study from Spain; Ibáñez et al. 2010) and quantitative data are lacking. The scarcity of records suggests that small warblers, larks, and buntings do not occur regularly in Mediterranean rice fields, which contradicts the selection criteria for focal species as defined by EFSA (2009). For these feeding guilds we had to consider more frequently occurring species (shorebirds, gulls) as potential focal species candidates. The large herbivorous "goose," represented by the greylag goose, is less relevant than the recommended herbivorous focal species mallard, as discussed earlier.

While flooding during the noncropping season is not very common, rice growers can generally have 2 different strategies to manage paddies after harvest: fields can be either flooded or dry (Elphick et al. 2010a; Longoni 2010; Lourenco and Piersma 2009). In addition, as described earlier, (temporary) dry cultivation during the actual growing season also occurs in Europe and pesticides may also be applied on dry soil. This is important for the risk assessment and particularly the focal species selection because different scenarios are relevant whether the rice fields are flooded or not due to the different bird and mammal species composition. One finding of this review is that most available wildlife occurrence data concentrates on flooded rice fields. In addition, the period of flooding generally corresponds to the period when pesticide exposure is most likely to occur, i.e., during rice cultivation. This review thus focused on potential focal species occurring in the wet environment of flooded rice paddies in spring and summer. For risk assessment of specific pesticides applied outside this period or on dry soil before flooding (e.g., seed treatments), the focal species selection likely has to be re-evaluated on a case-by-case basis.

The dominance of waterbirds in the widest sense (i.e., waders, gulls, ducks, geese, herons) in rice-growing regions in Asia, the Americas, Australia, and Africa supports our findings for rice fields in southern Europe (e.g., Acosta et al 2010; Fujioka et al. 2010; Gopi Sundar and Subramanya 2010; Mugica et al. 2006; Pierluissi 2010; Taylor and Schultz 2010; Wood et al. 2010; Wymenga and Zwarts 2010). Many species (mainly birds) associated with natural wetlands frequently also occur in rice paddies. For some globally declining species, rice paddies are of high conservation value (Fujioka et al. 2010), and they represent an important substitute for natural wetlands (Lourenco and Piersma 2009; Pierluissi 2010). Also in southern Europe the populations of some species rely on rice cultivation and flooded fields, e.g., the glossy ibis (Toral et al. 2012) or wintering black-tailed godwits (Lourenco and Piersma 2008). In general, most species regularly recorded in rice fields favor the rice plant growth stages that are associated with water (Toral et al. 2011). Consequently, flooded rice fields—independent of growth stage and assuming minimum pesticide usage—could function as a compensation for the loss of natural wetlands and are considered as a valuable conservation tool particularly during migration and winter periods (Pernollet et al. 2015; Toral and Figuerola 2010).

Hence, although the overall rice-growing area in the EU is rather small compared to other crops and the European rice production amounts to only a small percentage of the global rice production (FAOSTAT 2017), an adapted risk assessment scheme accounting for the highly specific environments of rice fields is important. This is also recognized by EFSA, who originally even envisaged a separate GD just for rice (as pointed out in EFSA 2009). Adaptations to the EU risk assessment procedures might also influence decision-making for pesticide registration in some of the main rice-producing areas of the world such as China or Brazil, since EU procedures are sometimes used as a baseline for development of country-specific registration requirements (Castro 2014; CCM 2017).

A total of 121 bird species from 13 different orders were recorded in rice fields in Europe, but there is an obvious bias (probably due to scientific interest) in published data for certain taxonomic groups (e.g., herons) while other groups are underrepresented (e.g., raptors, passerines). For the same reason (and probably also due to methodological difficulties) only 10 species of mammals were recorded in European rice fields. There is an obvious lack of data for small mammals (e.g., shrews, mice), which are difficult to obtain without specific trapping schemes.

Most of the recorded bird species visit rice fields only during specific periods, e.g., during migration, which is important information to be able to determine their potential exposure to pesticides. However, such information on the time of occurrence and/or abundances of recorded species is partly missing in the available studies. It is particularly difficult to obtain data on breeding birds in rice fields because access to nests is often not possible without damaging the rice plants, which is one of the main reasons for the low number of studies on rice fields as nesting habitat for birds (see Elphick et al. 2010a). A lower nesting success due to field management and subsequent damage of nests was noted across different bird taxa in 1 study, while nesting failure due to predation or use of chemicals has not been recorded so far (Pierluissi 2010).

In general, the occurrence of animal species in rice paddies varies not only between different periods but also between the different rice-growing regions. It has been suggested that such regional variation can, for instance, be attributed to differences in water management practices, rice plant structure, and potentially also pesticide use (by reducing food resources; Ibáñez et al. 2010; Longoni 2010). Furthermore, some rice-growing regions in Europe are situated in larger areas that naturally support high (and internationally important) numbers of birds (e.g., Albufera de València, Doñana and Ebro Delta in Spain or the Camargue in France). The variation in species composition and abundance during the rice-growing season thus needs to be taken into account. Specific focal species studies, conducted according to the criteria defined by EFSA (2009), could address this by providing more detailed data on quantitative occurrence of potential focal species during the relevant periods and crop growth stages (see Eisen Rupp et al. 2011 for a similar study in rice fields in Brazil).

However, although no such specific focal species studies have been conducted for birds in rice in Europe, there was sufficient data available from other publicly available studies to select focal species candidates for most foraging guilds that are by far more realistic than the ones currently stated for rice scenarios in the GD (EFSA 2009). In addition, information on the abundance and occurrence rates of bird species in the different countries in the southern registration zone can be estimated from the presented data from Spain and France because the candidate focal species generally occur in all relevant rice-growing countries.

No studies have been conducted to specifically identify focal mammal species in rice paddies for risk assessment purposes. The data available from public literature are based on rather incidental reports of mammals associated with rice fields but lack indication of the exact period of occurrence and location (i.e., in rice paddies or habitats neighboring rice paddies). The data that can be derived from diet analyses of birds foraging in rice paddies also have shortcomings (e.g., it is difficult to determine whether the mammal was captured in a rice paddy or not). However, although the available data on mammals in rice fields is more limited than for birds, they can be used for a preliminary identification of potential focal species candidates. It should be noted in this regard that other taxonomic groups also may be of importance in rice. For instance, amphibians seem potentially relevant

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considering the wet environment of rice paddies, but the availability of specific focal species data is currently likewise limited for this group, and future research would be needed to appropriately address this.

The example risk assessment presented in this review highlights the potential impact of using the suggested bird and mammal species in a rice scenario risk assessment. It shows that different scenarios and diet guilds would be considered relevant compared to the default assumptions for cereals and that the quantitative outcome can be different already at tier 1 level, where generic focal species of a certain feeding guild without further refinement are assessed. Appropriate higher tier refinements using ecological data for the suggested species would further influence the overall outcome and potentially the regulatory decision. The use of rice field specific focal species and scenarios would result in a more realistic risk assessment, potentially changing the quantitative outcome over that generated with the current guidance and improving decision making within the pesticide registration framework.

CONCLUSIONS

The proposed bird and mammal focal species presented in this review (Table 5) are considered as an initial proposal until further (quantitative) data—ideally from rice-specific focal species studies—become available. As discussed earlier, the selection of the proposed focal species was partly based on ecological relevance, e.g., in terms of distribution, frequency of occurrence, and seasonality related to migration and breeding status, while still considering the smallest of the determined relevant species from each diet guild as a conservative assumption (lower body weight means higher food intake rates per gram body weight; see also Dietzen et al. 2014 for selection criteria). Therefore, the selected species can be considered representative for all other relevant species of the corresponding feeding guilds as requested by EFSA (2009). Hence, while more data on bird and mammal species in rice would help to get a more detailed picture and to fine-tune the focal species selection, conducting risk assessments based on the focal species suggested in the present review would clearly be more realistic than using the focal species for cereals, as suggested for rice fields by EFSA (2009). Our results thus provide an important baseline for more substantiated and reasonable decision-making in the context of pesticide registration and may also support the development of a revised GD for birds and mammals.

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Data Accessibility—Supplemental data is included listing all bird species identified during the literature search.

SUPPLEMENTAL DATA

Table S1 Species, diet guild, and body weight of birds recorded in rice fields in southern Europe.

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