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Trends in High Nature Value farmland studies: A systematic review

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ABSTRACT

Background. Since the High Nature Value (HNV) concept was defined in the early 1990s, several studies on HNV farmland has been increasing over the past 30 years in Europe, highlighting the interest by scientific community of HNV farming systems supporting biodiversity conservation. The aim of this study was to evaluate the trends and main gaps on HNV farmland peer-reviewed publications in order to contribute to the effectiveness of future research in this field. Methods. Searches were conducted using the databases Web of Sciences™ and Scopus in order to identify only peer-reviewed articles on HNV farmland, published prior to July 2017. The inclusion and exclusion criteria were developed *a priori*. Data as year, country, type of document, subject area, taxa studied and biodiversity metrics assessed were extracted and explored in order to analyse the spatial and temporal distribution of the concept, including the main topics addressed in HNV farmland literature. Results. After screening 308 original articles, 90 were selected for this review. HNV farmland studies involved several disciplines, mainly biodiversity and conservation and environmental sciences and ecology. Most peer-reviewed articles focused on HNV farming were conducted in Spain, Italy, Ireland and Portugal. The main studied taxa were plants and birds. Taxonomic diversity was the biodiversity metric more often used to assess the biodiversity status on HNV farmland areas. A positive correlation was found between HNV farmland area and HNV farmland studies conducted in respective countries. Discussion. The HNV farmland research subject is a relative novel approach, and this systematic review provides a comprehensive overview about the main topics in the HNV farmland peer-reviewed literature contributing to highlight the main gaps and provide some considerations in order to assist the performance of HNV farming systems and conservation policies, addressed to sustain high levels of biodiversity.

KEYWORDS

agricultural biodiversity; biodiversity metrics; High Nature Value; farmland; farming systems; systematic review

INTRODUCTION

In the world but mostly in Europe, agricultural activities have shaped the landscape for centuries, even millennia. By definition, agricultural areas were created by human activity and represent artificial mosaics of different land use types (Donald et al. 2006). Currently, almost 40% of the world's terrestrial surface is used for agriculture land (Fahrig et al. 2011; Foley et al. 2011). In Europe, this percentage is increasing, with agricultural landscapes covering up to 60% of some countries (Tilman 1999; Fox 2004; Halada et al. 2011). Taking this into consideration and that at least 50% of species in Europe depend on agricultural habitats (Benton et al. 2003; Kristensen 2003; Stoate et al. 2009; Halada et al. 2011; EEA 2012), the essential role of agriculture in the conservation of biodiversity is evident. According to this, several studies have widely described that the impact of changes in farming practices constitutes one of most important causes of biodiversity decline (Tilman 1999; Halada et al. 2011), evidenced by the rise in productivity in the late 19th and 20th century which coincides with a widespread decline in farmland biodiversity (Bignal & McCracken 2000; Firbank et al. 2008). Specifically, the past decades have witnessed a strong decline in farmland biodiversity in Western Europe caused by intensification, abandonment and mechanisation of agricultural activities (Chamberlain et al. 2000; Donald et al. 2001; Lomba et al. 2014).

On the other hand, traditional agricultural systems generally characterised by low-intensity farming systems shaped European landscapes and were related for supporting high levels of biodiversity, especially those species listed as of conservation priority in the European Union (EU) Species and Habitats Directives (Beaufoy et al. 1994; Bignal & McCracken 1996; EEA 2004, 2009; Plieninger 2006; Commission 2011; Halada et al. 2011). Hence, those farming systems are denominated as 'High Nature Value farmland' (hereafter HNVf) (Beaufoy et al. 1994; Van Doorn & Elbersen 2012) and are characterised by predominantly semi-natural forage, very low livestock

densities per hectare, land under arable and permanent crops, combination of low nitrogen and low biocide inputs per hectare. Folks' traditional practices have coevolved with the natural environment and, consequently, created a landscape of high natural and cultural value dominated by humans for centuries (Beaufoy et al. 1994; Liu et al. 2007; Dorresteijn et al. 2015; Akeroyd 2016). So, many of HNVf, recognised for their greatest biodiversity value, are also considered as 'agri-cultural' landscapes or High Cultural Values (HCV).

HNVf are relevant, besides for economic reasons, because of the significant positive impact of biodiversity on agricultural production, waking up great interest and actions to sustain high biodiversity in agricultural systems (Tryjanowski et al. 2011; Dorresteijn et al. 2015). According to this, the European Community (EC) has launched initiatives to reduce the loss of biodiversity by 2020 (European Commission 2011). Contemporary, the Common Agricultural Policies (CAP) involved each country of the European community to take measures against biodiversity loss (Baldock et al. 1993; Bennett et al. 2006) by encouraging farmers, amongst other initiatives, to maintain the techniques of extensive agriculture and to preserve the characteristics of semi-natural landscapes (Baldock et al. 1993; Bennett et al. 2006; Morelli et al. 2014). In synergy with these measures, several studies have been carried out to define the HNVf concept by recognising HNV and to assess its performance in sustaining high biodiversity (Pointereau et al. 2007; Bartel 2009; Halada et al. 2011) reflected as nature value or conservation value (in this last case, the presence/occurrence of species/habitats under legal protection).

The HNV concept was defined in the early 1990s (Baldock et al. 1993; Beaufoy et al. 1994) as the several types of farming systems that promotes high levels of biodiversity or maintains species and habitats of conservation concern. Successively, Andersen et al. (2003) suggested a more detailed definition of HNVf as 'those areas in Europe where agriculture is the dominant land use and where agriculture supports or is associated with either a high species and habitat diversity or the presence of species of European conservation concern or both'. Thus, an HNVf indicator was established under the EAFRD (European Agriculture Fund for Rural Development) by implementing the Regulation 1974/2006/EC in order to introduce environmental concerns into the EU Common Agricultural Policy. Successively, the EU Rural Development Programme promotes HNVf as high priority agro-ecosystems, requiring each EU Member State to identify the dimensions and status of their HNVf as well as monitoring temporal trends (EC 2005; EENRD 2009). Since then, several scientific studies have focused on HNV farming systems in order to assess their effect on biodiversity and to monitor the quality and status of agro-ecosystems (Pointereau et al. 2010; Morelli 2013a, 2013b; Aue et al. 2014; Morelli & Girardello 2014; Morelli et al. 2014; Acebes et al. 2016).

As the contribution of peer-reviewed scientific literature focused on HNVf, its essential to the drafting of technical-scientific reports of the European Community and their consequent effect on HNVf initiatives (e.g. Baldock et al. 1993; Farmer et al. 2008; Paracchini et al. 2008), a systematic review of this literature could help to recognise pitfalls and aspects that need more development. Furthermore, a comprehensive analysis of the scientific articles could also provide tools for preventing biodiversity loss in agricultural environments.

In order to reach this goal, a systematic review involving a broad search of scientific articles was conducted. The analysis was focused only on peer-reviewed articles, considering that the scientific peer-review process is important for insuring the quality of published research (Larson & Chung 2012). More specifically, temporal trends, geographical distribution of studies, types of articles, main disciplines, taxa of focus in articles and type of metrics used to evaluate biodiversity were investigated. In addition, based on these findings, potential gaps in current HNVf knowledge were explored by identifying some challenges for future researches in order to contribute to the assessment on HNVf in sustaining biodiversity.

1. METHODS

1.1. Bibliographic research and selection of studies

In order to evaluate the trend and main gaps on HNVf publications, a comprehensive search of peer-reviewed articles published before July 2017 was conducted. The databases used were Web of Sciences™ (http://www.isiwebofknowledge.com) and Scopus (http://www.scopus.com); the following search terms were used in combinations on TITLE and TOPIC sections: (1) 'HNV farmland', (2) 'HNV farming', (3) 'High Nature Value farmland', (4) 'High Nature Value farming', (5) 'HNV' and (6) 'High Nature Value'. These were used to search title, abstract and full text. The selection of studies relevant for this systematic review was made in a two-stage process. First, relevance for the current study was initially assessed based on the article titles, abstracts and keywords. Second, the full text of all papers that are included in the final systematic review was analysed.

Non-peer reviewed articles; articles in languages other than English; non-original papers such as books, letters, editorials and summaries of conferences; historical papers; and papers without abstract were excluded. Some articles appeared in several academic databases and duplicate papers in the databases were also excluded.

From each examined paper, the following data were extracted: (1) year of publication, (2) country of research, (3) taxon studied, (4) topic or subject area, (5) type of document (original article or review) and (6) biodiversity measures used. All these variables were examined. If a study considered more than one parameter (e.g. country, taxon) each parameter was treated separately (Luck 2007).

1.2. Biodiversity metrics

The biodiversity metrics used in the articles were classified and grouped into the following categories: Taxonomic diversity, alpha/beta diversity, species abundance, species diversity/

evenness, functional diversity and others. Here follows a brief description of the main measures found in most HNVf studies:

Taxonomic diversity: This metric takes into account the number of species in a community (Magurran 2004). Further components of taxonomic diversity are represented by alpha diversity, which refers to the total number of species (species richness) within a particular area, community or ecosystem; and beta diversity, which refers to the species diversity amongst ecosystems (Tuomisto 2010).

Abundance of each species is very important for understanding the dynamics of populations (Mace & Lande 1991; Mace et al. 2008 from Yin) and is usually measured as the number of individuals per sample (Yin & He 2014). Species evenness takes into account the relative abundance of species in an area (Feest et al. 2010). Functional diversity is focused on the ecological traits of species (de Bello et al. 2010) and represents a key factor in ecosystem functioning (Naeem et al. 2012).

1.3. HNVf areas

The surface of HNVf area in each country is according to European Environment Agency (EEA, 2012; Table 5, col1); and in the case of Greece (which is not included in EEA 2012), it was provided by Paracchini et al. 2008 (Table 4, col1); the values are indicated in hectares (ha) and were used for correlation tests.

1.4. Statistical analysis

Statistical analyses were performed using R software (R Core Team 2016). The relationship between the hectares (ha) and number of HNVf studies by country was quantified by means of a Pearson correlation test. Relative frequencies and percentages of variables included in the review were calculated using SPSS v19 (SPSS Inc., Chicago).

2. RESULTS

The literature search resulted in 308 articles. After screening titles, abstracts and full text, 218 articles were excluded. A total of 90 peer-reviewed studies of HNV farming in Europe were identified for the present study, of which 84 were original articles and 6 were review articles.

HNVf research has been developing moderately; the number of scientific articles published from 2006 does not exceed 9 articles per year until 2015, after which it raised to 19 articles per year (Fig. 1). France published the first HNVf peer-reviewed article in 2006, whereas Italy and Portugal began publishing in this field only in the past years, 2010 and 2012, respectively (Table 1). Twenty-five European countries (4 non-EU member states and 21 EU member states) published peer-reviewed articles focused on HNV farming (Fig. 2). More than 15% of HNVf studies were focused on all of Europe (15.6%) (Table 1).

More than 68% of articles come from just seven countries: Spain, Italy, Portugal, Ireland, France and Romania. Southern European countries had many peer-reviewed articles focused on the HNVf: Spain (15.6%), Italy (13.3%), Portugal (12.2%) and France (8.9%) (Fig. 2). Especially, Italy has rapidly increased their research activities in this area recently. In northern Europe, Ireland has been the subject of several studies on HNV farming (12.2%). Romania stands out as the country of Central Eastern Europe with most studies on HNVf (6.7%),

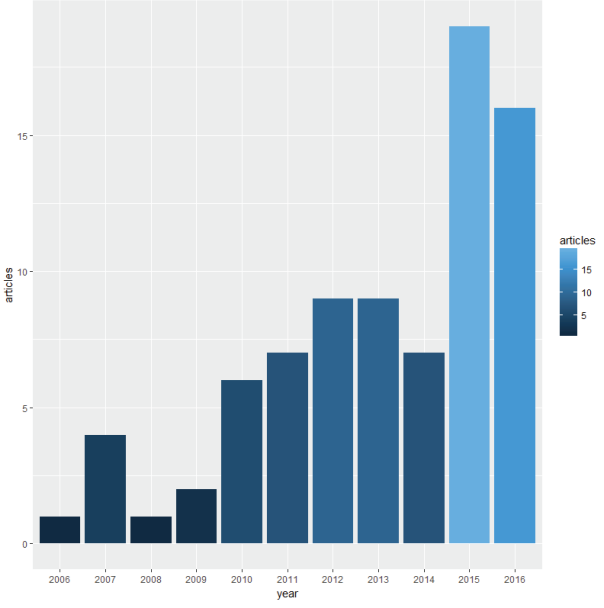

Figure 1. Number of peer-reviewed articles focused on HNVf published between 2006 and 2016.

Table 1. Comparison of High Nature Value farmland peer-reviewed articles in countries with higher amount of literature considering main topic and most studied taxa.

Country	Number of articles	Year of first publication	Topic: Biodiversity and conservation (%)	Taxa: Plants (%)	Taxa: Birds (%)
Europe	15	2008	40.0	13.3	6.7
Spain	14	2007	57.1	57.1	21.4
Italy	12	2010	66.7	41.7	33.3
Portugal	11	2007	81.8	54.6	9.1
Ireland	10	2007	60.0	30.0	0.0
France	8	2006	62.5	25.0	25.0
Romania	6	2007	66.7	50.0	0.0

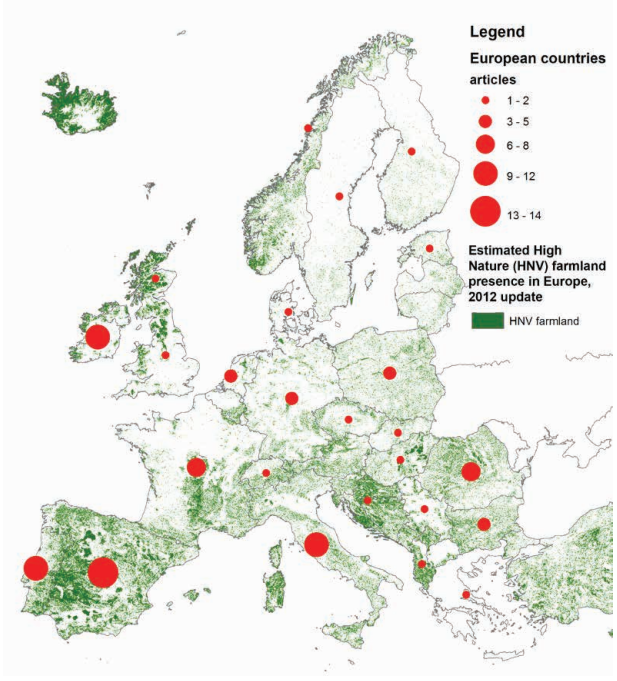

*Figure 2. Distribution of number of peer-reviewed publications on HNVf across Europe. The size of the red circles indicates the number of publications. Green areas show areas that contain estimated HNVf presence, based on the stratified selection of CORINE land cover 2006 classes per country and environmental zone and national biodiversity data when available. The values in the map are a proxy for the proportion of HNVf in each 1 km² cell, 2012 update. The map is provided in http://www.eea.europa.eu/legal/copyright. *Copyright holder: European Environment Agency (EEA)**

whilst all other EU countries have very low relative research activity in this area (1–3%) (Fig. 2).

The subject area with most articles was biodiversity and conservation (51%) followed by agricultural policies (27.8%) and environmental sciences and ecology (14.4%). The lowest contributions come from agricultural and biological sciences, veterinary sciences, public administration and behavioural sciences, with 1–2% (Table 2). Considering only countries with most HNVf studies, more than 60% of articles were focused on biodiversity and conservation topic (Table 1).

The taxa most studied were plants (35.6% of cases) and birds (18.9%), followed by insects (11.1%) and mammals (5.6%). Few studies were about amphibians, arachnid, bryophytes, lichens and reptiles (1.1%) (Table 2). Amongst countries with more HNVf studies (Table 1), more than 57% of publications from Spain were about plants and 21.4% were on birds. In the case of Ireland and Romania, 27% and 50%, respectively, of the articles were dedicated for plants but none for birds. On the other hand, Italy and France had produced most studies on birds (33.3% and 25%, respectively) (Table 1).

The biodiversity measures most frequently used to assess biodiversity status of HNV farming were taxonomic diversity (38.9%) followed by species diversity/evenness (6.7%), alpha/beta diversity (5.6%) and species abundance (4.4%).

Table 2. Summary of frequencies on diverse characteristics of High Nature Value farmland peer-reviewed articles.

Subject area	Articles	%
Biodiversity and conservation	46	51.1
Agricultural policy	25	27.8
Environmental sciences and ecology	13	14.4
Agricultural and social sciences	2	2.2
Agricultural and biological sciences	2	2.2
Veterinary sciences	1	1.1
Behavioural sciences	1	1.1
Taxa	**Articles**	**%**
Plant	32	35.6
Bird	17	18.9
Insect	10	11.1
Mammal	4	4.4
Amphibian	1	1.1
Arachnid	1	1.1
Bryophytes	1	1.1
Lichen	1	1.1
Biodiversity metrics	**Articles**	**%**
Taxonomic diversity	36	40.0
Species diversity/evenness	6	6.7
Alpha/beta diversity	5	5.6
Species abundance	4	4.4
Others	2	2.2
Functional diversity	2	2.2

Other biodiversity metrics such as functional diversity were less explored and showed low percentages (2.2%) (Table 2).

The number of articles by country was positively correlated with HNVf area (ha) of each country. The correlation was strong (Pearson $r = 0.66$) and significant ($P < 0.01$). However, comparing the relative percentages of number of articles with the relative percentages of HNVf areas by country, it is also possible to highlight that Ireland, Italy and Portugal are the countries with most HNVf studies compared with the HNVf area of their respective countries. In this sense, Spain is the country with fewest studies in relation to HNVf area (Fig. 3).

3. DISCUSSION

Systematic reviews are the best tool for synthesising primary results about the topics of interest (Haddaway & Bilotta 2016). In this systematic review, a synopsis of the most influential scientific peer-reviewed literature on HNV farming in Europe in the past 30 years is provided. The EU and national agricultural and environmental policies and large amounts of research and

funding are dedicated to biodiversity conservation approaches (Farmer et al. 2008), which after several years begins to take shape as witnessed by growing attention and focus on the subject area, and underscored by the increasing number of peer-reviewed articles about HNVf.

HNV research is a relatively novel approach introduced in the early 1990s when the term was established by Baldock et al. 1993a, and scientific peer-reviewed articles focused on HNVf only appeared gradually. Articles about HNVf increased markedly from 2006, with articles from France followed by Spain in 2007. Possibly, this slow growth of scientific publications is due to earlier efforts going into EU reports of guidelines in order to define, classify and assess HNV farming areas. However, a high positive slope is observed just since 2015 with 20 articles per year. In fact, Italy in 2010 and Portugal in 2012 were the countries with most items in recent years.

These results show how HNV farming systems have attracted attention from multiple disciplines using heterogeneous approaches, with a multidisciplinary outlook spanning ecology, veterinary, agricultural, social and public administration. However, only two disciplines were prevalent on published articles: biodiversity and conservation and environmental sciences, indicating a large effort and involvement from ecology focused mainly on biodiversity assessment of HNVf areas, with minor contribution from other disciplines. However, some studies in other disciplines outside ecology could be higher but maybe several authors omit to include the word or acronym HNV in key places of the paper such as title, abstract and keywords, remaining outside from the selection criteria.

However, according to Janssen and Goldsworthy (1996), many questions about natural resource management including HNVf research cannot be addressed adequately through a single research discipline, raising the need to stimulate multidisciplinary work. For example, several HNVf have also HCV, being then High Natural and Cultural Value farmland (Dorresteijn et al. 2015). Several authors showed for Transylvania that whilst the natural value of farming landscapes is of exceptional importance, population suffer from poverty, mistrust and several conflict (Akeroyd 2016). Furthermore, values associated with landscapes are deteriorating. Indicating that a more strong association between environmental and social sciences is needed as key for a more resilient support to biodiversity by HNV policies (Dorresteijn et al. 2015; Akeroyd 2016).

Previous articles have highlighted clear differences between Western and Eastern European farmland, emphasising diverse patterns of biodiversity within EU farmland by comparing intensive versus more extensive agricultural landscapes (Baldi et al. 2011; Tryjanowski et al. 2011). This indicates important differences in social and ecological systems that impact on conservation strategies linked to biodiversity (Tryjanowski et al. 2011). This finding concurs in showing a considerable geographic bias. Most peer-reviewed articles about biodiversity assessment of HNVf areas come from southern Europe, including Spain, Italy and Portugal. In northern Europe, Ireland produced the most HNVf articles. Fewer than 20% of HNVf papers come from Central and Eastern European countries, with Romania as the country with most. These results demonstrate that the distribution of HNVf peer-reviewed articles throughout Europe was not geographically uniform. The potential causes of this spatial heterogeneity of HNVf studies were explored by considering the geographical distribution of HNVf across European countries. The strong correlation between number of HNVf peer-reviewed articles and surface of HNVf areas in each country found in this analysis indicates a greater effort of HNVf research in countries with larger HNVf areas, as can be expected. However, because the effort should also be reflected in increased effectiveness of conservation policies, it is indispensable to expand local or point studies towards regional and continental scales (Schimel 2011).

Furthermore, in an attempt to understand if spatial distribution of HNVf studies was driven by the presence of HNV areas, or is also reflecting a differential interest in the HNV topic in each country, we calculated the ratio between HNVf studies and HNVf area (Fig. 3). A high value of HNVf studies as a function of HNVf surface could be an indicator of high scientific interest, which may also indicate greater potential effectiveness on conservation policies, whilst lower values can reflect less potential effectiveness. Portugal, Italy and Ireland have highest number of publications per HNVf surface (see Fig. 2). However, Spain, with most HNVf peer-reviewed articles published and large surface of HNVf, has fewer studies in relation to HNVf surface. It is also important to consider two aspects about this comparison: first, the HNVf values provided by EEA (2012) and Paracchini et al. (2008) could overestimate the area in some European countries, whilst underestimating that in others (Paracchini et al. 2008) and second, reports and grey literature on HNVf, even if were not included in this study, could provide additional information on the HNVf.

It is currently impossible to carry out a complete inventory of organisms by direct enumeration. So, indirect but effective solutions are necessary (May 1990; Ehrlich 1992). A

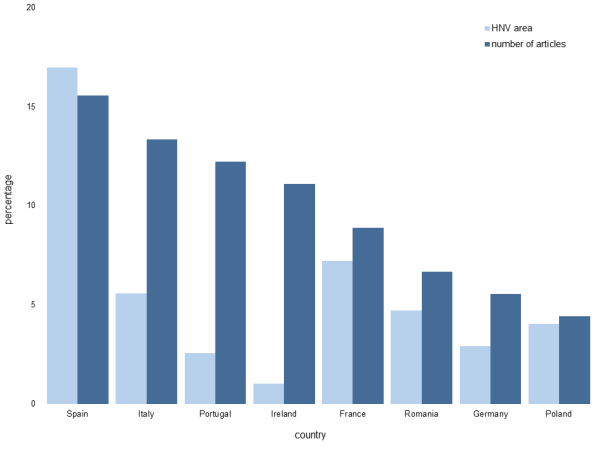

Figure 3. Bar chart of area of HNVf (ha) represented as a percentage of the number of peer-reviewed HNVf articles (blue bar) and HNVf area by country (light-blue bar) (EEA, 2012); both variables are relativized by total HNVf Europe area (EEA, 2012) and total number of peer-reviewed HNVf articles.

reasonable approach involves bioindicators that provide partial measures or estimator surrogates of biodiversity (Sarkar & Margules 2002). In order to assess biodiversity distribution across HNVf areas, some studies revealed that taxa such as birds and plants are useful bioindicators of biodiversity in HNV farming systems. This concurs with McKinney (2002), who argues that birds, mammals and plants are the best-studied taxa along urban–rural gradients (Mckinney 2002). Countries differed in taxa that were considered in HNVf studies. Italy produced more studies on birds, whilst Spain produce more studies on plants (Table 1). Italy, Portugal, Romania and France generated studies focused on both birds and plants. However, just few studies were focused on other taxa such as invertebrates, mammal, amphibian or reptiles. This can reflects that many people are interested mainly on diversity of few groups, principally plants and birds (Williams et al. 1997). However, a multi-taxa approach would be important for effective conservation policies, for recognising areas of high natural value and for assessing and monitoring biodiversity (Hannah et al. 2002).

Finally, the most used biodiversity metrics was taxonomic diversity. However, in order to obtain a wider vision of the biodiversity sustained by HNV farming systems, it is necessary to also focus more on other biodiversity metrics than taxonomic diversity or species richness. Using mainly species richness misses the ecological role and contributions of individual species to ecological communities (Safi et al. 2013). Another inconvenience involved is the global diversity assessment. Whilst global biodiversity has declined rapidly (e.g. Pereira et al. 2012), it is possible that whilst some communities lose species, others simultaneously gain other species, both native and exotic species, that change their range or niche in response to environmental changes (McKinney & Lockwood 1999). Thus, paradoxically, whilst global biodiversity is declining, species richness measures can locally increase (Sax & Gaines 2003). A clear and concise definition of biodiversity is impossible to obtain (Noss 1990), but, generally, functional diversity is better described by ecosystem function than species richness or other measures of taxonomic diversity (Petchey et al. 2004). Another dimension to consider for assessing diversity in communities is the phylogenetic diversity (PD). The PD is gaining increasing recognition in community ecology, macro-ecology and conservation biology (Cadotte et al. 2010; Davies & Cadotte 2011) as being important for evolutionary relationships and for understanding and predicting biological and ecological processes (Tucker et al. 2016). Indeed, PD is important because phenotypic, genetic and behavioural differences exist amongst evolutionary lineages (Harvey & Pagel 1991).

As summary, these results show how HNV farming is a stimulating and growing research field where incipient directions are starting to crystallise. However, the analyses have highlighted that in order to adequately assess the role of HNVf in sustaining biodiversity and its conservation, it is necessary

- To increase the geographical range covered by HNVf peer-reviewed articles to fill in knowledge gaps in Europe;
- To expand the HNVf studies to other, less-studied taxa, such as mammals, insects, arachnids, amphibians and reptilians, and to fill taxa gaps in several areas (e.g. birds in Spain, Ireland or Romania);
- To assess HNV farming biodiversity using other biodiversity metrics, especially measures of functional diversity (Devictor et al. 2010; Morris et al. 2014; Zupan et al. 2014) in addition to other aspects related to community composition such as PD (Jetz et al. 2014; Tucker et al. 2016);
- To improve the research effort as a function of HNVf area in each country, taking into account the use of bioindicators (Noss 1990) and also considering the effect of multispatial scale in different landscapes (Morelli et al. 2013) by understanding the many factors driving biodiversity patterns in HNV farming systems;
- In order to recognise and transmit anymore the natural and strategic values of these HNVf, it is necessary to alleviate the bias on HNVf literature. Thus, it is suggested to researchers on HNVf to 'flag' their articles with HNV acronym in the title, abstract or keywords in order to better recognise the peer-reviewed publication during selection process;
- Finally, based on these findings, it is really necessary to enhance the synergies amongst related research disciplines, in order to better understand the effects of HNV farming on biodiversity and the relative roles of anthropogenic factors and natural processes.

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1. ELECTRONIC SUPPLEMENTARY MATERIAL

Table S1. List of 90 peer-reviewed articles that were focused on HNV are included in this systematic review, indicating the references from where we obtained the data.

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