Risk analysis report of non-native organisms in Belgium

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Risk analysis of the Reeves' muntjac *Muntiacus reevesi*

Wallonie

Université de Liège

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Etienne Branquart (Cellule Espèces Invasives, Service Public de Wallonie) developed the risk analysis template that was used for this exercise.

The general process of drafting, reviewing and approval of the risk analysis for selected invasive alien species in Belgium was attended by a steering committee, chaired by the Federal Public Service Health, Food chain safety and Environment. RBINS/KBIN was contracted by the Federal Public Service Health, Food chain safety and Environment to perform PRA's for a batch of species. ULg was contracted by Service Public de Wallonie to perform PRA's for a selection of species. INBO and DEMNA performed risk analysis for a number of species as in-kind contribution.

Steering committee members were:

Tim Adriaens	Research Institute for Nature and Forest (INBO)
Olivier Beck	Brussels Environment (BIM)
Roseline Beudels-Jamar	Royal Belgian Institute of Natural Sciences (RBINS/KBIN)
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Rationale and scope of the Belgian risk analysis scheme

The Convention on Biological Diversity (CBD) emphasises the need for a precautionary approach towards non-native species. It strongly promotes the use of robust and good quality risk assessment to help underpin this approach (COP 6 Decision VI/23). More specifically, when considering trade restrictions for reducing the risk of introduction and spread of a non-native organisms, full and comprehensive risk assessment is required to demonstrate that the proposed measures are adequate and efficient to reduce the risk and that they do not create any disguised barriers to trade. This should be seen in the context of WTO and free trade as a principle in the EU (Baker et al. 2008, Shine et al. 2010, Shrader et al. 2010).

This risk analysis has the specific aim of evaluating whether or not to install trade restrictions for a selection of absent or emerging invasive alien species that may threaten biodiversity in Belgium as a preventive risk management option. It is conducted at the scale of Belgium but results and conclusions could also be relevant for neighbouring areas with similar eco-climatic conditions (e.g. areas included within the Atlantic and the continental biogeographic regions in Europe).

The risk analysis tool that was used here follows a simplified scheme elaborated on the basis of the recommendations provided by the international standard for pest risk analysis for organisms of quarantine concern[1] *produced by the secretariat of the International Plant Protection Convention (FAO 2004). This logical scheme adopted in the plant health domain separates the assessment of entry, establishment, spread and impacts. As proposed in the GB non-native species risk assessment scheme, this IPPC standard can be adapted to assess the risk of intentional introductions of non-native species regardless the taxon that may or not be considered as detrimental (Andersen 2004, Baker et al. 2005, Baker et al. 2008, Schrader et al. 2010).*

The risk analysis follows a process defined by three stages : (1) the <u>initiation process</u> which involves identifying the organism and its introduction pathways that should be considered for risk analysis in relation to Belgium, (2) the <u>risk assessment stage</u> which includes the categorization of emerging non-native species to determine whether the criteria for a quarantine organism are satisfied and an evaluation of the probability of organism entry, establishment, spread, and of their potential environmental, economic and social consequences and (3) the <u>risk management stage</u> which involves identifying management options for reducing the risks identified at stage 2 to an acceptable level. These are evaluated for efficacy, feasibility and impact in order to select the most appropriate. The risk management section in the current risk analysis should however not been regarded as a full-option management plan, which would require an extra feasibility study including legal, technical and financial considerations. Such thorough study is out of the scope of the produced documents, in which the management is largely limited to identifying needed actions separate from trade restrictions and, where possible, to comment on cost-benefit information if easily available in the literature.

This risk analysis is an advisory document and should be used to help support Belgian decision making. It does not in itself determine government policy, nor does it have any legal status. Neither should it reflect stakeholder consensus. Although the document at hand is of public nature, it is important to realise that this risk assessments exercise is carried out by (an) independent expert(s)

[1] A weed or a pest organism not yet present in the area under assessment, or present but not widely distributed, that is likely to cause economic damages and is proposed for official regulation and control (FAO 2010).

who produces knowledge-based risk assignments sensu Aven (2011). It was completed using a uniform template to ensure that the full range of issues recognised in international standards was addressed.

To address a number of common misconceptions about non-native species risk assessments, the following points should be noted (after Baker et al. 2008):

- *Risk assessments are advisory and therefore part of the suite of information on which policy decisions are based;*
- *The risk assessment deals with potential negative (ecological, economic, social) impacts. It is not meant to consider positive impacts associated with the introduction or presence of a species, nor is the purpose of this assessment to perform a cost-benefit analysis in that respect. The latter elements though would be elements of consideration for any policy decision;*
- *Completed risk assessments are not final and absolute. New scientific evidence may prompt a re-evaluation of the risks and/or a change of policy.*

Executive summary

PROBABILITY OF ESTABLISHMENT AND SPREAD (EXPOSURE)

Entry in Belgium	Casual observations of muntjac deer were regularly reported from Kempen and West Vlaanderen in recent years, which may lead to species establishment in the future. Accidental escape from captivity and deliberate release into the wild are the two most probable introduction pathway that can occur for this species in Belgium. A natural spread from the Netherlands where small local free-ranging populations start to establish is also possible.
Establishment capacity	This species has a high establishment capacity from a limited number of individuals thanks to its strong plasticity and its high intrinsic rate of natural increase. It is very likely that muntjac deer could establish in Belgium since climatic, habitat and food requirements are fully encountered. Establishment in Ardenne is less likely because of colder climate with a long period of snow cover.
Dispersion capacity	This species has a moderate range expansion capacity (1km/year), which may be strongly enhanced as a result of human translocation and illegal introduction into the wild. The rate of spread is predicted to be moderate in Belgium as well, and potentially slower in Maritime, Flandrian and Brabant districts because of a strong habitat fragmentation.

EFFECT OF ESTABLISHMENT

Environmental impacts	Muntjac deer may easily reach high local densities. Field observations performed in GB show that this could cause a strong and irreversible impact on ground layer and shrub vegetation and a modification of the structure and the composition of woodland habitats, leading to cascade effects on invertebrate and vertebrate communities. Muntjac deer may also outcompete the native roe deer* locally but should not affect its viability on the long term at a regional scale.

RISK MANAGEMENT

Establishment of muntjac deer due to escape from captive populations hold in deer parks, ornamental collections or zoos may occur in Belgium in the coming years and is considered as more likely than an expansion from existing populations in neighbouring countries. The prohibition of its importation and trade and the strengthening of the holding interdiction together with awareness raising could therefore be considered as efficient measures for reducing the risk of establishment to an acceptable level.

Where deer parks are already present and have to be maintained (e.g. in public zoos), escape and establishment risk should be reduced through the adoption of drastic security measures including ear-tagging and systematic sterilization of captive deer combined with the obligation to register existing collections and to rapidly report any escape.

Those preventive measures have to be preferred over early detection and population control as the muntjac deer may easily establish feral populations after escape. It is a very discreet animal that is difficult to detect and to cull. So far, no muntjac population has been extirpated through eradication actions. Successful density control and containment are difficult to achieve and cannot be reached without the collaboration of all landowners, and without a good, intensive and coordinated approach involving well trained hunters that are sharing the management goal and are consequently willing to contribute actively to a significant reduction or to the containment of the local muntjac populations. A further awareness raising among the hunting community and education on the possible negative consequences of the presence of the species will be essential to reach this purpose.

Résumé

PROBABILITE DE NATURALISATION ET DE DISSEMINATION DANS L'ENVIRONNEMENT

Introduction en Belgique	Des observations ponctuelles du muntjac ont été régulièrement rapportées en Campine et en Flandre occidentale ces dernières années, préalable à une possible naturalisation de l'espèce durant les prochaines années. Les évasions accidentelles d'individus en captivité et la libération délibérée de l'espèce dans la nature sont les deux voies d'introduction les plus probables en Belgique. Une dispersion naturelle à partir des Pays-Bas, où de petites populations sauvages commencent à s'établir localement, pourrait aussi constituer une autre voie d'introduction sur le long terme.
Capacité de naturalisation	Cette espèce possède une grande capacité de naturalisation à partir d'un nombre limité d'individus grâce à sa grande plasticité et à son taux intrinsèque de croissance naturelle élevé. Il est très probable que le muntjac puisse s'implanter en Belgique car l'ensemble des conditions climatiques, d'habitats et de ressources alimentaires nécessaires à sa naturalisation sont rencontrées. L'implantation du muntjac est moins probable en Ardenne en raison de la rigueur du climat hivernal sur les hauts plateaux.
Capacité de dispersion	Cette espèce a une capacité d'expansion modérée (1 km/an), laquelle peut toutefois être amplifiée par des transferts ou des introductions illégales dans la nature. En Belgique, on s'attend à un taux de dispersion modéré et potentiellement plus lent dans les districts maritime, flandrien et brabançon en raison d'une forte fragmentation de l'habitat.

EFFET DE LA NATURALISATION

Impacts environnementaux	Le muntjac peut facilement atteindre des densités locales élevées. Des observations de terrain effectuées en Grande-Bretagne montrent que la surdensité du muntjac peut avoir un impact majeur et irréversible sur les sols et la végétation arbustive et entraîner une modification de la structure et de la composition des habitats forestiers. Ceci peut conduire à des effets en cascade sur les communautés d'invertébrés et de vertébrés. Le muntjac pourrait aussi réduire localement les populations de chevreuil par compétition avec celui-ci sans toutefois porter atteinte à sa viabilité à long terme au niveau régional.

GESTION DU RISQUE

L'évasion de muntjacs détenus dans des parcs animaliers (chez des particuliers ou dans les zoos) constitue la voie d'entrée la plus probable de cette espèce en Belgique, avant l'expansion naturelle de ce cervidé à partir de populations naturalisées dans les pays voisins. L'interdiction de son importation et de son commerce ainsi que le renforcement de l'interdiction de détention combinés à des campagnes de sensibilisation constituent des mesures efficaces de réduction du risque d'implantation.

Là où des parcs à cervidés existent déjà et doivent être maintenus (p. ex. dans les zoos publics), le risque d'évasion et d'implantation doit être réduit par l'adoption de mesures draconiennes de sécurité comprenant entre autre le marquage d'oreille et la stérilisation systématique des individus captifs, combinés à l'obligation d'enregistrement des populations existantes et de notification rapide des cas d'évasion.

Ces mesures de prévention doivent être préférées aux mesures de détection précoce et d'éradication des populations. Le muntjac est un animal qui a la capacité d'établir facilement des populations férales et est en outre très difficile à détruire en raison de ses mœurs discrètes. Aucun cas d'éradication réussie d'une population de muntjacs n'a été rapporté jusqu'à ce jour. Le confinement ou la régulation de leurs populations sont difficiles à réaliser. Cet objectif ne pourrait être réalisé qu'au travers d'une approche régionale coordonnée, fondée sur un partenariat avec les propriétaires fonciers et des chasseurs bien entraînés et déterminés à éliminer l'espèce. La sensibilisation des conseils cynégétiques aux nuisances produites par le muntjac sera essentielle pour atteindre cet objectif.

Samenvatting

WAARSCHIJNLIJKHEID VAN VESTIGING EN VERSPREIDING (BLOOTSTELLING)

Introductie in België	De afgelopen jaren werden er sporadisch meldingen gemaakt van muntjak in de Kempen en in West Vlaanderen; dit kan erop wijzen dat deze hertachtige zich in de toekomst zal vestigen. De twee meest waarschijnlijke introductiewegen voor muntjak in België zijn toevallige ontsnapping uit gevangenschap en het opzettelijk uitzetten ervan in het wild. Anderzijds behoort ook natuurlijke verspreiding vanuit Nederland, waar kleine, plaatselijke, vrij levende populaties zich beginnen te vestigen, ook tot de mogelijkheden.
Vestigingsvermogen	Dankzij haar hoge plasticiteit en de potentieel hoge aanwas van de soort, slaagt deze erin zich met een beperkt aantal individuen in zich snel te vestigen. De kans dat muntjak zich in België vestigt is vrij groot, omdat onze contreien perfect tegemoet komen aan de vereisten van de soort op het vlak van klimaat, habitat en voedsel. Doordat de koude periode in de Ardennen langer aanhoudt, is het weinig waarschijnlijk dat de soort zich in dat deel van België zal kunnen vestigen.
Verspreidingsvermogen	De soort beschikt over een matig vermogen om zijn leefgebied uit te breiden (1 km/jaar); dat echter aanzienlijk vergroot kan worden door opzettelijke translocaties door de mens en (in België verboden) uitzetting in het wild. Verwacht wordt dat de verspreidingssnelheid in België zich op een matig niveau zal situeren en in de kuststreek, Vlaamse en Brabantse districten door de sterke fragmentering van geschikt habitat wellicht zal vertragen.

EFFECTEN VAN DE VESTIGING

Milieu-impact	Muntjak kan plaatselijk gemakkelijk zeer hoge densiteiten bereiken. Veldwaarnemingen in Groot-Brittannië tonen aan dat dit een sterke en onomkeerbare impact kan hebben op de kruidlaag en op de struikvegetatie en een verandering van zowel de structuur en als de samenstelling van boshabitats kan veroorzaken, wat op zijn beurt dan weer gevolgen kan hebben voor bosfauna. Muntjak kan plaatselijk ook het inheemse ree verdringen, maar zou de leefbaarheid op regionaal niveau van deze algemene soort op lange termijn vermoedelijk niet aantasten.

BESLUIT VAN HET GEDEELTE RISICOBEHEER

In de komende jaren valt niet uit te sluiten dat deze soort zich vestigt uit ontsnapte populaties die in gevangenschap in hertenparken, siercollecties of dierenparken leven. Die introductieweg valt meer te vrezen dan de uitbreiding van bestaande populaties in de buurlanden. Daarom dienen een verbod op de invoer en de verkoop, en een verstrengd toezicht op het verbod tot houden van deze soort, samen met een grotere sensibilisering, te worden beschouwd als efficiënte maatregelen om het risico op vestiging tot een aanvaardbaar niveau terug te brengen.

In het geval van te handhaven bestaande hertenparken (bv. in openbare dierentuinen) kunnen enkel drastische veiligheidsmaatregelen het risico op ontsnapping en vestiging terugdringen. Die kunnen bestaan in het oormerken en systematisch steriliseren van herten in gevangenschap, gecombineerd met verplichte registratie van bestaande collecties en de onverwijlde meldplicht van ontsnappingen.

Preventieve maatregelen dienen de voorkeur te krijgen boven een vroege detectie en populatiecontrole omdat na ontsnapping verwilderde populaties zich snel kunnen vestigen. Muntjak is een erg schuw dier dat moeilijk valt op te sporen. Tot dusver is men er nog niet in geslaagd om de soort met succes uit te roeien. Een succesvolle densiteitscontrole blijkt bijzonder moeilijk zonder de samenwerking van alle landeigenaars ; verder vereist dit ook een intensieve en gecoördineerde benadering waarbij goed opgeleide jagers worden betrokken die hetzelfde beheerdoel nastreven en bijgevolg bereid zijn actief tot een aanzienlijke vermindering of beheersing van de plaatselijke muntjakpopulatie bij te dragen. Een verdere sensibilisering onder de jagersgemeenschap en educatie over de mogelijke negatieve gevolgen van de aanwezigheid van de soort zullen noodzakelijk zijn om dit doel te bereiken.

STAGE 1: INITIATION

Precise the identity of the invasive organism (scientific name, synonyms and common names in Dutch, English, French and German), its taxonomic position and a short morphological description. Present its distribution and pathways of quarantine concern that should be considered for risk analysis in Belgium. A short morphological description can be added if relevant. Specify also the reason(s) why a risk analysis is needed (the emergency of a new invasive organism in Belgium and neighboring areas, the reporting of higher damage caused by a non native organism in Belgium than in its area of origin, or request made to import a new non-native organism in the Belgium).

1.1 ORGANISM IDENTITY

Scientific name : *Muntiacus reevesi* Ogilby, 1839
Common names : Reeves' Muntjac (GB), Chinesischer Muntjak (DE), Muntjak (NL), Muntjac (FR).
Taxonomic position: Chordata (Phylum) > Mammalia (Class) > Artiodactyla (Order) > Cervidae (Family).

<u>Note</u>: There are twelve species of *Muntiacus* deer (distributed from Pakistan and China through South-East Asia to Borneo), only one of which (*M. reevesi*) is frequently hold in private collections and occurs as an invasive species in Europe. Muntjac specimens imported in Europe refer to the *Muntiacus reevesi reevesi* subspecies native from mainland China. Little is known about its biology and status in China, but its invasion history in Great Britain is well documented (Chapman *et al.* 2004 & 2005, Putman 2009, Ward & Lees 2011).

1.2 SHORT DESCRIPTION

Muntjac deer are small forest deer weighing 9-18 kg and having a shoulder height of about 0.5m high when standing (Corbet & Harris 1991, Putman 2009). To compare, roe deer* (*Capreolus capreolus*) has an adult life weight of 20-30 kg and a height of 0.65-0.85m (Jacques 2000). Male muntjac deer are characterized by small backwardly-directed simple antlers and enlarged upper canine tusks (Putman 2009).

1.3 ORGANISM DISTRIBUTION

Native range

The native range of *Muntiacus reevesi* consists of subtropical forests of south-eastern and central China, and Taiwan, as illustrated in figure 1 (Deuling 2004, Leasor *et al.* 2008). In its native range, it is exploited for the industrial trade, and suffers from habitat loss. It is considered as a “Least Concern” species according to IUCN (Leasor *et al.* 2008).

Figure 1: Native range of *Muntiacus reevesi* (Leasor *et al.* 2008)

Introduced range

Belgium:	The species is not established in Belgium, but casual reports of animals killed in traffic accidents do occur.
Rest of Europe:	Extensive feral muntjac deer populations are established in the United Kingdom since several decades (Grubb 2005, Ward 2005, Chapman 2008, Putman 2009). Small recent free-roaming populations are also reported from France, Ireland and the Netherlands (Southern 1964, Nowak & Paradiso 1983, Chapman *et al.* 1994, Helin *et al.* 1999, Deuling 2004, Putman 2009, Carden *et al.* 2011).
Other continents:	Muntjac deer is locally established and considered as invasive in Japan (Southern Chiba Prefecture and Izu islands) (Asada *et al.* 2009, Odashi *et al.* 2009).

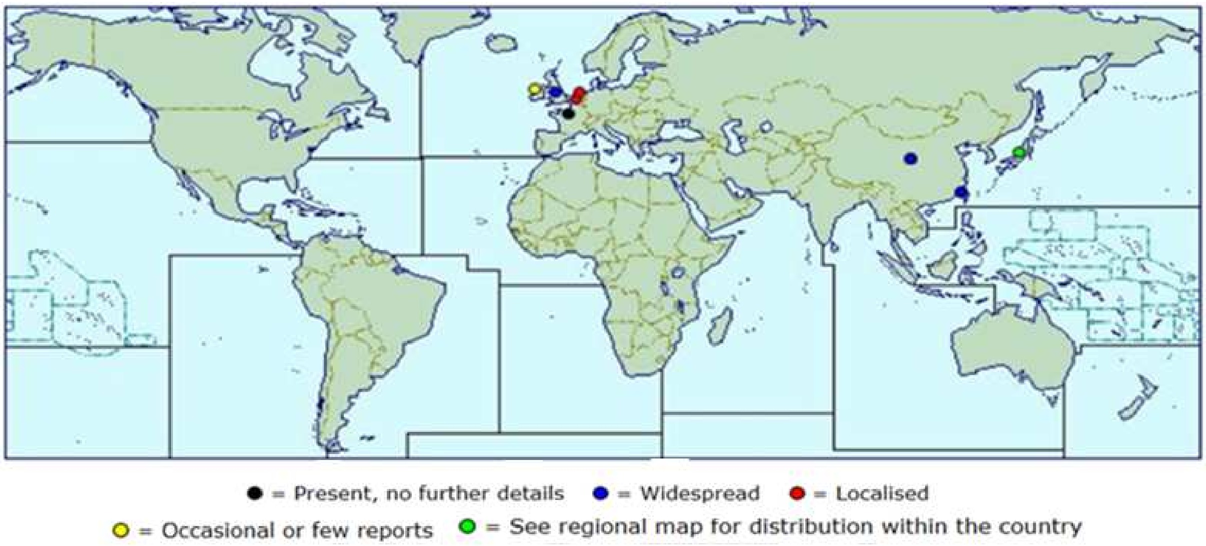


Figure 2: Distribution of the species *Muntiacus reevesi* in the world (Putman 2009).

1.4 REASONS FOR PERFORMING RISK ANALYSIS

Muntjac deer may escape and be released in the wild from captive populations in Belgium, where it may establish feral populations given the Atlantic weather conditions. Experience from the United Kingdom (and Japan) demonstrate that this species is likely to rapidly increase population size thanks to a high intrinsic growth rate and to cause strong detrimental impacts on native biodiversity.

2.1 PROBABILITY OF ESTABLISHMENT AND SPREAD (EXPOSURE)

Evidence should be available to support the conclusion that the non-native organism could enter, become established in the wild and spread in Belgium and neighbouring areas. An analysis of each associated pathways from its origin to its establishment in Belgium is required. Organisms intentionally imported maybe maintained in a number of intended sites for an indeterminate period. In this specific case, the risk may arise because of the probability to spread and establish in unintended habitats nearby intended introduction sites.

2.1.1 Present status in Belgium

Specify if the species already occurs in Belgium and if it makes self-sustaining populations in the wild (establishment). Give detail about species abundance and distribution within Belgium when establishment is confirmed together with the size of area suitable for further spread within Belgium.

Although some isolated sightings were increasingly reported from 2008 onwards, e.g. near Brugge (2008-2012), Mol-Neerpelt (2008-2013), Braschaat (2009-2013) and Hasselt (2010-2013) (http://observations.be), the species is not yet considered as truly established in Belgium. The origin of those animals is unknown except for Braschaat where animals came from a captive population in a private property (INBO). It is not excluded that some immigrants may also come from the Netherlands.

2.1.2 Present status in neighbouring countries

Mention here the status of the non-native organism in the neighbouring countries

Following the original introduction to Woburn Park, Bedordshire in 1894 and subsequent secondary releases, an extensive feral muntjac deer population is established in southern Britain, with large concentrations observed in England (figure 3). Muntjac now becomes the most widespread deer species in England, where it is observed in a wide range of habitats, including urban areas. Its distribution is principally clumped into five counties (Berkshire, Buckinghamshire, Hertfordshire, Oxfordshire and Warwickshire), with elsewhere scattered and low population densities probably due to recent colonization or releases (accidental or deliberate). The current total pre-breeding population in England and Wales is estimated at around 250,000 individuals (Chapman *et al.* 1994, Harris *et al.* 1995, Grubb 2005, Ward 2005, Chapman 2008, Putman 2009, Ward & Etherington 2010, Ward & Lees 2011). Since 2007, substantiated reports on muntjac deer presence in the East of Ireland (and anecdotal reports concerning the North and the Northwest of Ireland) have been highlighted. The exact range and population size of muntjac in Ireland is not known with certainty (Dick *et al.* 2009, Carden *et al.* 2011).

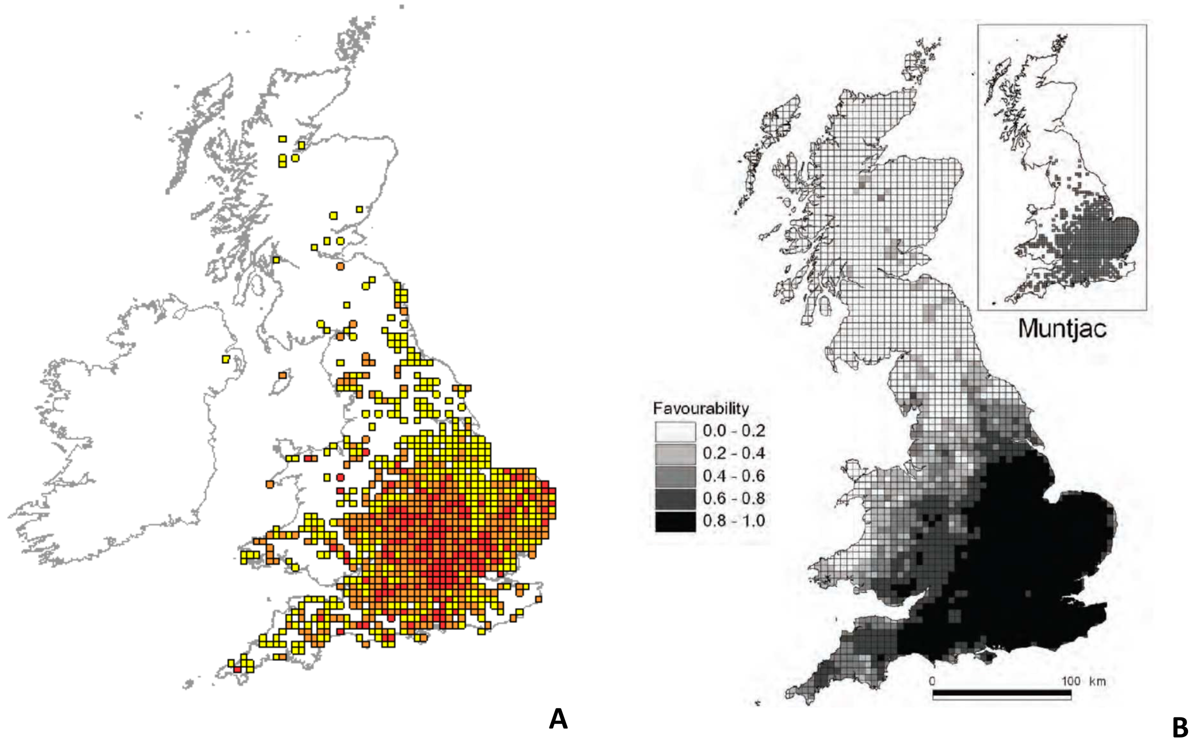


Figure 3 – Distribution of *Muntiacus reevesi* in Great Britain. A.: evolution of 10km distribution: top (red) : 1950-1969, middle (orange) : 1970-1989 and bottom (yellow) : 1990-2009 (NBN Gateway). B.: species favourability according to the model developed by Acevedo *et al.* (2010).

Confirmed sightings of single and multiple free-roaming muntjac deer were reported from the Netherlands since 2005 (Noord-Brabant and Gelderland) as a likely result of different release or escape events (see figure 4 from http://waarneming.nl). The total number is estimated at around 50-100 units gathered in at least 2 isolated subpopulations but it is not known to what extent a population is building up (Van Wieren & Groot Bruinderink 2010). If the experience of England is repeated in the Netherlands, self-sustaining populations could slowly establish in the wild during several decades before growing and spreading rapidly (Ward & Lees 2011). The possibility of a future expansion from the small isolated populations observed the Netherlands causes a real concern for the colonization of large areas in continental Europe and the potential adverse impacts they could generate (Putman 2009).

Sighting of escaped muntjac deer were also regularly reported from France but no evidence of current establishment has been found in the scientific literature so far (Southern 1964, Nowak & Paradiso 1983, Chapman *et al.* 1994, Helin *et al.* 1999, Deuling 2004, Grubb 2005, Réseau ongulés sauvages 2013).

Figure 4 – Sightings of muntjac deer in the Netherlands from 2005 onwards (data: http://waarneming.nl).

2.1.3 Introduction in Belgium

Specify what are the potential international introduction pathways mediated by human, the frequency of introduction and the number of individuals that are likely to be released in Europe and in Belgium. Consider potential for natural colonisation from neighbouring areas where the species is established and compare with the risk of introduction by the human-mediated pathways. In case of plant or animal species kept in captivity, assess risk for organism escape to the wild (unintended habitats).

Three different pathways might cause muntjac establishment in Belgum: (i) escape from private collections, (ii) illegal deliberate release into the wild and (iii) natural spread from neighbouring areas (Putman 2009, Ward & Lees 2011).

As in other European countries, muntjac deer are regularly introduced in zoos and ornamental collections in Belgium; recent import movements have been e.g. reported towards the animal parks of Cambreau-Casteau (Paradisio), Bocholt (Het Veldhof) and Ucimont (AFSCA-FAVV database). Future escapes of muntjac from those parks and zoos is likely to occur as it regularly happened in neighboring countries, due to accidental destruction of fences for example. In Southern Britain, the loss of just a few individuals from captive breeding has allowed the establishment of many feral populations (Southern 1964, Nowak & Paradiso 1983, Chapman *et al.* 1994, Helin *et al.* 1999, Ward & Lees 2011).

During the last decades, numerous deliberate releases of muntjac deer have been done as game because of their antlers for trophy hunters in Western Europe, mostly in the United Kingdom but also in Belgium, France, Ireland and Japan. Actually, muntjac deer were firstly considered as a benign invasive species, until they increased in density and distribution, and became harmful to the environment by browsing plants of conservation importance, etc. (Macdonald & Tattersall 2001, Cooke & Farrell 2002, Nenwtwig 2007, Putman 2009). In the UK for example, ten licenses were delivered to release hospitalized muntjac deer in 1997 with the consent of the Advisory Committee on Releases of non-native organisms to the Environment[2]. Although most countries today prohibit deliberate exotic ungulate introductions, multiple illegal releases are still known to occur nowadays both in Ireland and the United Kingdom (Chapman *et al.* 1994, Carden *et al.* 2010, Ward & Lees 2011).

In case of establishment and range expansion of muntjac deer in the Noord-Brabant province of the Netherlands (figure 4), a natural spread towards Belgium will inevitably occur in the coming decades. The first suitable areas to colonize are the woodland areas of Kempen (Antwerpen and Limburg provinces), where sightings are regularly reported (see section 2.1.1).

ENTRY IN BELGIUM

Casual observations of muntjac deer were regularly reported from Kempen in recent years, which may lead to species establishment in the future. Accidental escape from captivity and deliberate release into the wild are the two most probable introduction pathway that can occur for this species in Belgium. A natural spread from the Netherlands where small local free-ranging populations start to establish is also possible.

2.1.4 Establishment capacity and endangered area

Provide a short description of life-history and reproduction traits of the organism that should be compared with those of their closest native relatives (A). Specify which are the optimal and limiting climatic (B), habitat (C) and food (D) requirements for organism survival, growth and reproduction both in its native and introduced ranges. When present in Belgium, specify agents (predators, parasites, diseases, etc.) that are likely to control population development (E). For species absent from Belgium, identify the probability for future establishment (F) and the area most suitable for species establishment (endangered area) (G) depending if climatic, habitat and food conditions found in Belgium are considered as optimal, suboptimal or inadequate for the establishment of a reproductively viable population. The endangered area may be the whole country or part of it where ecological factors favour the establishment of the organism (consider the spatial distribution of preferred habitats). For non-native species already established, mention if they are well adapted to the eco-climatic conditions found in Belgium (F), where they easily form self-sustaining populations, and which areas in Belgium are still available for future colonisation (G).

A/ Life-cycle and reproduction

Life-history traits

Muntjac deer have a lifespan of 18 years in captivity, and live on average up to 10-12 years in the wild, perhaps longer in places without predators and with high food abundance as in England (Nowak & Paradiso 1983, Grzimek 1990, Chapman *et al.* 1994, Deuling 2004). In their native range (subtropics), breeding can occur all the year, but in Europe (especially in England) muntjac deer have more seasonal cycles and breeding (polygynous) occurs generally between October and March (Deuling 2004, Marchant 2011).

[2] Taken from the Newsletter of the Advisory Committee on Releases to the Environment (ACRE) (website).

In native range, muntjac deer is known to be able to recover rapidly and expand from low population levels thanks to a high intrinsic rate of natural increase (r_m = 0.43) (Thompson 1987, Steinmetz *et al.* 2010). The reproductive potential of *M. reevesi* is considered as quite high in England as well, even if r_m cannot be calculated with precision from field data due to difficulties to accurately monitor population densities and because of much of the spread was historically assisted by human introductions (R. Putman, pers. comm.). The high rate of increase of muntjac deer is the result of (i) a short gestation period of more or less 7 months (single fawns), (ii) a rapid development of fawns that are weaned after 2 months and reach reproductive maturity at approximately 6 months for females and 9 months for males, (iii) the poly-oestrous and post-partum oestrus of females that can start a new reproduction cycle immediately after young birth and (iv) a very high adult doe pregnancy rate approaching 100% (Grzimek 1990, Chapman *et al.* 1997, Deuling 2004, Chapman 2008, The deer initiative 2008). For comparison, female roe deer* reach sexual maturity at 14 months old, they are monoestrous, and the gestation period is about 260-320 days (10 months on average) (Jacques 2000). **Both a low weaning age and an early sexual maturity were identified by Fautley *et al.* (2012) as key factors promoting the establishment of deer species outside their native range.**

Muntjac deer are potentially long-lived animals. The longest survival of marked individuals in the wild is 13 years (female). Demographic data from several sites in southern England are as follows: mortality by one year is 56%, by two years 69%, by three years 75%, by four years 81%, by five years 88% and 100% by15 years (Chapman 2008).

Population density

Muntjac densities and relative abundances have been assessed through different techniques (direct distance sampling, camera traps, dung counting, etc.) in British ecosystems, where **densities from 20 to 120 animals per km^2 may occur in the absence of culling**. Muntjac deer often reach higher numerical density than other co-occurring deer species (Harris *et al.* 1995, Hemami *et al.* 2005, Putman & Ward 2010, Ward & Etherington 2010, Ward & Lees 2011). In contrast with roe deer* for which many population estimates are available, there are few estimates of muntjac density due to its secretive behaviour (Cooke 2006, Hemami *et al.* 2007).

B/ Climatic requirements[3]

Muntjac deer is native to subtropical forests and prefer warm temperate climate with dry summer and dry winter (Putman 2009). **They have adapted well to ecoclimatic zones of England and Wales while Scotland, being colder with a shorter growing season, is less favorable** (see figure 3). In southern Britain, heavy mortality has been observed due to extreme winter conditions with long periods of deep snow cover which made foraging difficult and cause starvation and pneumonia. Warmer winter and lower seasonability (i.e. variability in seasonal temperature) are correlated with increased population growth rates and environment favourability (Pickvance & Chard 1960, Chapman *et al.* 1994, Harris *et al.* 1995, Cooke 1996, Cooke *et al.* 1996). However, there is no

[3] Organism's capacity to establish a self-sustaining population under Atlantic temperate conditions (Cfb Köppen-Geiger climate type) should be considered, with a focus on its potential to survive cold periods during the wintertime (e.g. plant hardiness) and to reproduce taking into account the limited amount of heat available during the summertime.

evidence of increased fawn mortality in most winters amongst the British feral population and it is unlikely that adverse weather conditions will limit population growth on the long term. Future climatic conditions (warmer winters) are likely to favour this aseasonal breeder by being comparable to climatic conditions in their native range (Cooke 2004, Acevedo *et al.* 2010, Fuller & Gill 2010, GB non-native species secretariat 2011).

C/ Habitat preferences[4]

In its native range, muntjac deer inhabits preferably temperate scrubs and dense primary forests in the tropical and semi-tropical zones, at moderate elevations of 200-400 metres of altitude (Nowak & Paradiso 1983, Chapman *et al.* 1994, Geist 1998, Helin *et al.* 1999, McCullough *et al.* 2000, Deuling 2004, Leasor *et al.* 2008). It may also occur in mountain habitats but there is a decreasing trend in abundance with increasing altitude (Leasor *et al.* 2008).

In the UK, the muntjac deer occurs in a **wide range of habitats with dense vegetation** as observed for roe deer* and there is often a high habitat overlap between these two species, which is the greatest in winter when both use bramble as an important food resource (Chapman *et al.* 1993, Hemami *et al.* 2004). They usually prefer dense permanent cover in woodland or scrub, in particular areas with a diverse year-round ground flora and shrub layers (especially with the presence of bramble and raspberry) and a high tree species diversity (mature nut-bearing trees in particular), with access to arable farmland. They are mainly present in a variety of lowland woodland types as broadleaved and dense deciduous, mixed conifer/broadleaf or coniferous woodlands, temperate forest edges, coppices, scrubs and young unthinned plantations. They tolerate human disturbance and adapt to both traffic and people. **Muntjac also use anthropogenic habitats like orchards, improved grasslands, grassy road verges, urban parks and gardens where they found a wide variety of suitable plants** (Chapman *et al.* 1985 & 1994, McCarthy & Rotherham 1994, Harris *et al.* 1995, Cooke 2004, Hemami *et al.* 2004 & 2005, Ward 2005, Chapman 2008, GB Non-Native Species Secretariat 2011).

D/ Food habits[5]

Muntjac are concentrate selectors, i.e. **selecting small food items readily digestible and of high nutritive value** due to their small gut size and simple digestive system (Hofmann 1985, Tixier *et al.* 1997, Cooke 2004). As a result they are primarily browsers rather than grazers, but also select herbs and forbs of high nitrogen content, as well as fruit. They have **a wide trophic niche** and a great variety of plant organs are browsed depending on seasonal availability, including tender shoots, leaves, seeds, flowers, fruits and bark (Deuling 2004, Hemami *et al.* 2004, Putman 2009). They may also occasionally feed on eggs, carrions and ground-nesting birds (Marshall 1967, Hofmann 1985, Grzimek 1990, Tixier *et al.* 1997, Burrage 2000, Deuling 2004, GB Non-Native Species Secretariat 2011). **In all seasons, bramble and raspberry usually account for a large proportion of their diet** (Harris & Forde 1986, Hemami *et al.* 2004).

[4] Including host plant, soil conditions and other abiotic factors where appropriate.

[5] For animal species only.

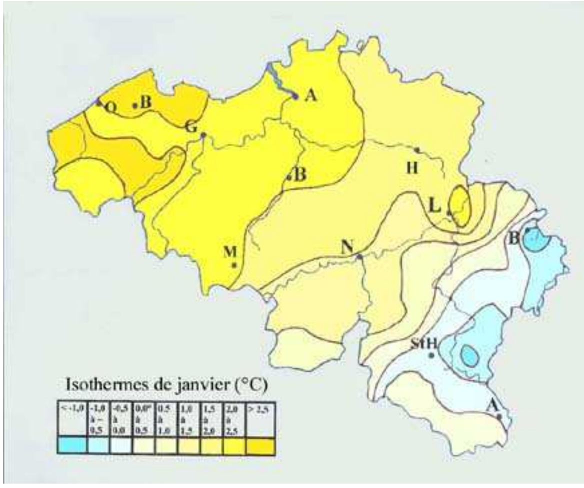
E/ Control agents

The regular expansion rate of muntjac deer in Great Britain (see section 2.1.5) demonstrates that natural enemies do not affect very much species fitness in Western Europe, where the species does not have important natural predators (Cooke 2004, Deuling 2004, GB Non-Native Species Secretariat 2011). Only red foxes (*Vulpes vulpes*)* are likely to slightly reduce its population growth rate through the predation on calves; anecdotal reports suggest that muntjac deer and red fox densities may be negatively correlated in the field (Harris *et al.* 1995, Chapman & Harris 1996, Deuling 2004, GB Non-Native Species Secretariat 2011).
It its native and introduction range, muntjac can be infected by bovine tuberculosis *Mycobacterium bovis*, foot-and-mouth disease virus and bovine viral diarrhea virus causing debilitating effects. Research on the consequences of those infections on ungulate population dynamics is rather limited and the potential impacts on the populations of Reeves' muntjac are largely unknown. Such diseases are however likely to cause mortality and play a regulatory role at high population densities (Gibbs *et al.* 1975a & 1975b, Cooke *et al.* 1996, Battersby 2005, Gortazar *et al.* 2006 & 2007, Böhm *et al.* 2007, East *et al.* 2011).
Other agents currently controlling muntjac deer densities are hunting and road collisions (Harris *et al.* 1995, GB Non-Native Species Secretariat 2011).

F/ Establishment capacity in Belgium

Muntjac deer have a high adaptability to different environments and easily adapted to the eco-climatic conditions found in England. **It is likely to also easily establish self-sustaining populations in Belgium, especially in areas where agricultural and native woodland elements are well represented.** A colonization of suburban habitats is also expected as observed in England. Muntjac establishment and population growth rate are likely to be favoured by the increasing abundance of *Rubus fruticosus* observed in the deciduous forests all over Western Europe due to a change in canopy cover and composition and due to atmospheric nitrogen deposition (Verheyen *et al.* 2012).

It may be assumed that muntjac capacity to establish self-sustaining populations is high under Atlantic temperate conditions but lower under the continental conditions found in the southern part of Belgium, where important mortalities may occur during the winter time (figure 5).



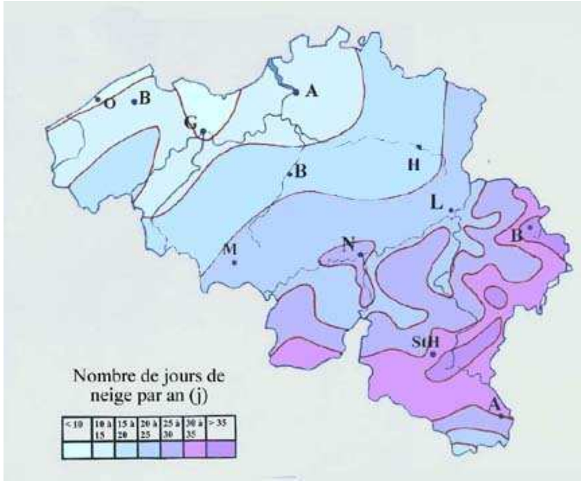


Figure 5 - Belgian maps of the mean temperatures in January (left) and of the number of snow days per year (right) established from 1900 to 1960 (data: Belgian Royal Meteorological Institute). They clearly identify a cold area in the Southern part of the country, with climatic conditions comparable to those prevailing in the Uplands and Highlands in Scotland. This area mainly includes the Ardenne district, where a deep snow cover is likely to persist during the wintertime and make it unfavourable to muntjac establishment.

G/ Endangered areas in Belgium

Based on the elements developed in previous sections, it may be assumed that muntjac deer may colonise most of the Atlantic region of the Belgian territory with the exception of industrial areas and of very intensive agricultural landscapes deprived of forest elements. They may thrive in any type of semi-natural woodland community, which includes all Natura 2000 forest types. Because of the hard winter conditions and the shorter vegetation period of the Ardenne district, it is considered as suboptimal for muntjac establishment, depending on altitude.

Establishment capacity in the Belgian geographic districts:

Districts in Belgium	**Environmental conditions for species establishment**[6]
Maritime	Optimal
Flandrian	Optimal
Brabant	Optimal
Kempen	Optimal
Meuse	Optimal
Ardenne	Suboptimal
Lorraine	Optimal

[6] For each district, choose one of the following options : optimal, suboptimal or inadequate.

ESTABLISHMENT CAPACITY AND ENDANGERED AREAS IN BELGIUM

This species has a high establishment capacity from a limited number of individuals thanks to its plasticity and its high intrinsic rate of natural increase. It is very likely that muntjac deer could establish in Belgium since climatic, habitat and food requirements are fully encountered. Establishment in Ardenne is less likely because of colder climate with a long period of snow cover.

2.1.5 Dispersion capacity

Specify what is the rate of dispersal once the species is released or disperses into a new area. When available, data on mean expansion rate in introduced territories can be specified. For natural dispersion, provide information about frequency and range of long-distance movements (i.e. species capacity to colonise remote areas) and potential barriers for spread, both in native and in introduced areas, and specify if the species is considered as rather sedentary or mobile. For human-assisted dispersion, specify the likelihood and the frequency of intentional and accidental movements, considering especially the transport to areas from which the species may easily colonise unintended habitats with a high conservation value.

A/ Natural spread

Home range

Because of the difficulties to collect occurrence data in dense vegetation habitats, information on muntjac range sizes is usually considered as poorly available from its native range (Marshall 1967, Chapman *et al.* 1993). However, results from one study performed in the mountain forests of Taiwan indicate that its home range size was about 100 hectares with no difference between sexes (McCullough *et al.* 2000). In UK, radio-tracking studies suggest that muntjac individuals are very sedentary and territorial year-round with a small and fixed home range, which is around 10-30 hectares depending on habitat quality and diversity (Chapman *et al.* 1993, Keeling 1995, Staines *et al.* 1998, Deuling 2004). Muntjac deer are in general solitary animals, and that in both sex, but are sometimes found in pairs (doe with juvenile or buck with doe) (Chapman 2008). Adult male territories are larger than females ones, don’t overlap with other male ranges, but may overlap the ranges of several females. Mean daily distances travelled by adult muntjac deer varies between 800 and 1200 metres (Chapman *et al.* 1993).

Dispersal distance

High local muntjac population densities amplify competition and force individuals to disperse into areas of lower population densities, especially in muntjac deer because adult males are territorial defending their home range, which leads to a range expansion (Böhm *et al.* 2007). As observed with most deer species, muntjac dispersal from their natal range occurs predominantly among juveniles, and males tend to achieve the greatest distances. Most movements do not exceed 5 kilometres but some individuals may travel up to 15-20 kilometres (Harding 1986, Chapman & Harris 1996, Ward 2005).

Expansion rate

Muntjac deer have considerably increased their ranges and abundance in Britain in the last 40 years, and even more rapidly than native roe* and red deer*. From surveys of deer presence in 10 km squares between 1972 and 2002, the Reeves' muntjac range is estimated to have expanded at a compound rate of 8.2% per year (Battersby 2005, Ward 2005). Its strong expansion rate (about 2.4 km/year) is the result of a combination of natural dispersal and multiple releases including deliberate introductions and escapes from parks. **The natural rate of spread is about 1 km/year**, which is rather comparable to that of roe deer but much less than the rate of spread of colonizing populations of sika deer. Muntjac dispersion rate is enhanced by suitable habitat continuity, namely the presence of woodland areas, but probably also by the presence of nutritious neighbouring croplands including winter cereals (Harding 1986, Alverson *et al.* 1988, Chapman *et al.* 1994, Sinclair 1997, Fuller & Gill 2001, Ward *et al.* 2008, Ward & Lees 2011). Because of strong habitat fragmentation, expansion rate is predicted to be slower in Maritime, Flandrian and Brabant than in other districts in Belgium

B/ Human assistance

In Britain, human assistance has been identified as an important component of the expansion of the Reeves' muntjac (see previous point).

DISPERSAL CAPACITY

This species has a moderate range expansion capacity (1km/year), which may be strongly enhanced as a result of human translocation and illegal introduction into the wild. The rate of spread is predicted to be moderate in Belgium as well, and potentially slower in Maritime, Flandrian and Brabant districts because of a strong habitat fragmentation.

2.2 EFFECTS OF ESTABLISHMENT

Consider the potential of the non-native organism to cause direct and indirect environmental, economic and social damage as a result of establishment. Information should be obtained from areas where the pest occurs naturally or has been introduced, preferably within Belgium and neighbouring areas or in other areas with similar eco-climatic conditions. Compare this information with the situation in the risk analysis area. Invasion histories concerning comparable organisms can usefully be considered. The magnitude of those effects should be also compared with those caused by their closest native relatives.

2.2.1 Environmental impacts

Specify if competition, predation (or herbivory), pathogen pollution and genetic effects is likely to cause a strong, widespread and persistent decline of the populations of native species and if those mechanisms are likely to affect common or threatened species. Document also the effects (intensity, frequency and persistency) the non-native species may have on habitat peculiarities and ecosystem functions, including physical modification of the habitat, change to nutrient cycling and availability, alteration of natural successions and disruption of trophic and mutualistic interactions. Specify what kind of ecosystems are especially at risk.

As for other deer species, **the potential impacts of Reeves' muntjac are typically density-dependent**. They are evaluated on the basis of damages observed in England, where muntjac deer may form dense feral populations and often reach higher numerical density than other co-occurring deer species (Harris *et al.* 1995, Chapman 2008, Putman *et al.* 2011).

A/ Competition

Several field studies performed in England demonstrate that muntjac often coexist with other deer species and that a substantial overlap in habitat use and diet occurs between muntjac and roe deer*, especially in winter when feeding resources are limited and both species do aggregate on bramble (Hosey 1981, Hearney & Jennings 1983, Harding 1986, Forde 1989, Chapman *et al.* 1993, Hemami *et al.* 2004).

In southeast England, **muntjac has been shown to be a better exploitative competitor than roe deer*** leading to a depletion of shared forage resources. Correlational data recorded over the last decades show that as the population of muntjac increased, roe deer* locally suffered habitat displacement, underwent a significant decline of body weight and fertility rates and significantly reduced their numbers (Wray 1992, Chapman *et al.* 1993, White *et al.* 2004, Hemami *et al.* 2005). An advantage of muntjac over roe deer* is also suggested by modeling results showing that higher environmental favourability values are observed locally in the southeast of England for the former species. In those conditions, muntjac appears to be environmentally closer to its optimal requirements; it may alter habitat suitability and exclude roe deer* when resources become limited. However, both species may compete in equal terms and coexist in other site conditions, which suggests that there is no immediate threat to the long term viability of native roe deer* in England (Acevedo *et al.* 2010, R.J. Putman, pers. comm.).

B/ Herbivory

When local muntjac density exceeds 25 to 50 animals per 100 ha, **muntjac deer may strongly damage ground flora, tree seedlings and coppice re-growth**. An intensification of the browsing and grazing damages has been observed during the last decades in England as a result of the increase of the muntjac and fallow deer populations whose feeding activities strongly supplement these of native deer species (Fuller & Gill 2010, Putman *et al.* 2011).

Damage may be very severe on specific plant species due to the muntjac habit to actively select specific food items with a high nutritive value (see section 2.4.1). **Muntjac eat ground level flowering plants to a greater extent than other deer and cause a dramatic decrease in flowering of vernal ancient forest plants growing in some conservation woodlands**, like *Anemone nemorosa*, Arum maculatum*, Cardamine pratensis*, Dactylorhiza fuchsii*, Hyacynthoides non*-scripta*, *Mercurialis perennis*, Primula* spp.* and *Orchis mascula** (Rackham 1975, Tabor 1993, Cooke 1994, Cooke *et al.* 1995, Cooke 1997, Diaz & Burton 1998, Gill 2000, Cooke 2005, Cooke 2006, The deer initiative 2008). The long-term vegetation monitoring performed in Monks Wood showed that the browsing activity of muntjac deer may locally induce a decline of overall plant richness, a loss of threatened species and the replacement of ancient forest plants by a grass-dominated vegetation tolerant to grazing by muntjac (figure 6). **Some of those changes may be irreversible; the presence of dense stands of grasses and sedges were shown to inhibit both the tree regeneration and the recovery of vernal herb species, even after a reduction in deer density** (Kirby 2001 & 2005, Cooke 2005).

Persistent browsing by muntjac deer may also cause a failure of tree regeneration and completely inhibit coppice regrowth. The impact on seedling regeneration or coppice regrowth becomes generally significant starting estimated densities of 25 muntjac deer per 100 ha. Young shoots need to attain a height of 1 metre to reduce their vulnerability (Symonds 1985, Tabor 1993, Cooke & Lakhani 1995, Bows 1997, Langbein 1997, Cooke 1998, Putman & Moore 1998, Cooke & Farell 2001, Cooke 2006, Putman *et al.* 2011).

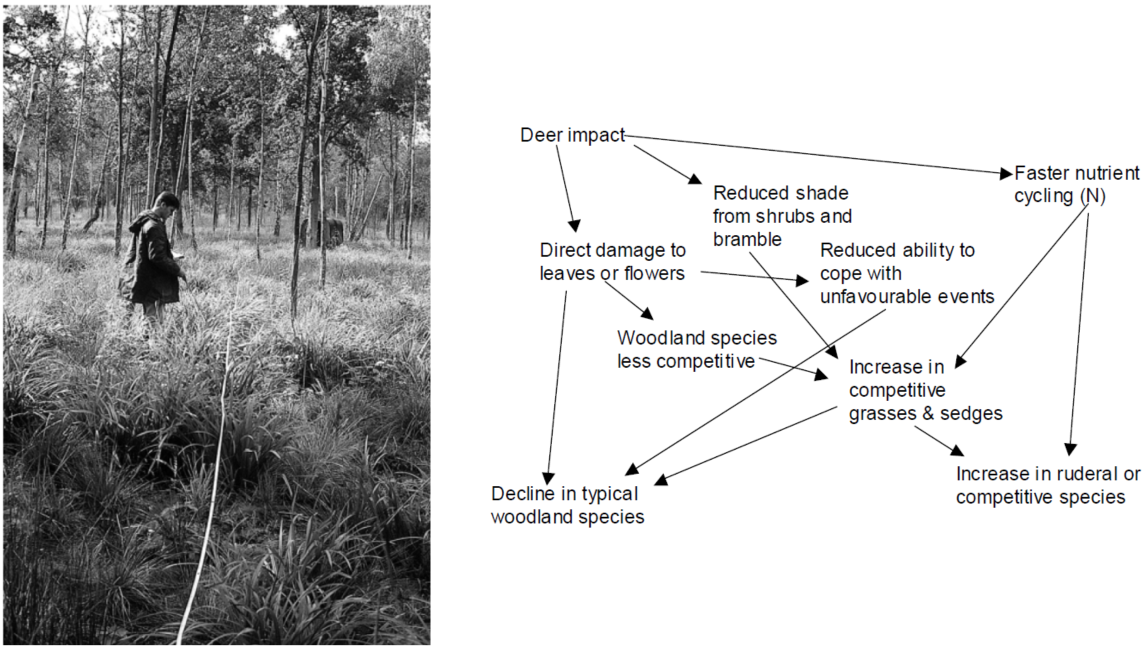


Figure 6 – Impact of muntjac browsing on the vegetation change in Monks Wood Nature Reserve, Cambridgeshire. Left: failure of coppice re-growth and development of a dense grass layer in the early 1990s (photo: Arnie Cooke). Right: Possible pathways by which muntjac deer may have influenced the vegetation changes (after Kirby 2005).

C/ Genetic effects and hybridization

In its native range, Reeves' muntjac (*Muntiacus reevesi*) can hybridize with Indian muntjac (*Muntiacus muntjak*) and give birth to an infertile progeny. In Europe however, Reeves' muntjac doesn't reproduce with native deer species and hybrids have never been reported (Shi *et al.* 1980, Shi & Pathak 1981, Chapman 2008).

D/ Pathogen pollution

As for native and other introduced deer species, muntjac deer are possible source of bovine tuberculosis, foot-and-mouth disease virus and the bovine viral diarrhea virus (Battersby 2005, Böhm *et al.* 2007). Because these diseases are typically density-dependent and transmission is realized by direct respiratory or ingestion contact, it cannot be excluded that they may be locally enhanced and spillback to native deer species as a consequence of muntjac establishment (Radostits *et coll.* 1994, Böhm *et al.* 2007, Zanella *et al.* 2008, Martin *et al.* 2011). No introduction of new diseases native to Asia through muntjac deer translocation has been documented so far.

E/ Effects on ecosystem functions

As observed with other deer species, browsing by Reeves' muntjac may **strongly modify the structure and the composition of woodland vegetation** when present at high densities. The progressive disappearance of the understory it generates is also likely to affect animal communities (Chapman *et al.* 1994, Pollard & Cooke 1994, McShea *et al.* 1997, Gill 2000, Cooke & Farrell 2001, Kirby 2001, Cooke 2004, Deuling 2004, Stone *et al.* 2004, GB Non-Native Species Secretariat 2011).

The reduction of the understory caused by muntjac browsing and grazing directly impacted woodland bird communities in England, with a strong decrease of shrub nesting species like the common nightingale (*Luscinia megarhynchos*)*, the song thrush (*Turdus philomelos*)*, the garden warbler (*Sylvia borin*)*, the willow warbler (*Phylloscopus trochilus*)* and the Eurasian bullfinch (*Pyrrhula pyrrhula*)* (Fuller *et al.* 2005).

As another example, an impact on the butterfly *Ladoga camilla** was documented in Monks Wood as a result of a shortage in egg-laying sites (Pollard & Cooke 1994, Cooke 2004, GB Non-Native Species Secretariat 2011). A decline of the population of small rodent species (e.g. *Apodemus* spp.*, *Myodes glareolus**, *Muscardinus avellanarius** and *Sorex* spp.*) and their predators (*Mustela* spp.* and *Vulpes vulpes**) was also shown as a result of the loss in feeding sites and shelter (Burrage 2000, Cooke & Farrell 2001, Flowerdew & Ellwood 2001, Fuller 2001, Stewart 2001).

At last, a modification of the pattern of nutrient cycles through consumption of material in some areas and dunging in others should not be excluded (Kirby *et al.* 2001).

ENVIRONMENTAL IMPACTS

Muntjac deer may easily reach high local densities. Field observations performed in GB show that this could cause a strong and irreversible impact on ground layer and shrub vegetation and a modification of the structure and the composition of woodland habitats, leading to cascade effects on invertebrate and vertebrate communities. Muntjac deer may also outcompete the native roe deer* locally but should not affect its viability on the long term at a regional scale.

2.2.2 Other impacts

A/ Economic impacts

Describe the expected or observed direct costs of the introduced species on sectorial activities (e.g. damages to crops, forests, livestock, aquaculture, tourism or infrastructures

In England and Wales, muntjac deer are thought to do relatively little damage to agriculture due to their small size and incapacity to graze completely grown cereal crops. They may however cause local problems in gardens, tree nurseries and horticultural crops unless adequately fenced (Chapman *et al.*

1994, Chapman & Harris 1996, Putman & Moore 1998, White *et al.* 2004, Putman 2009, GB non native species secretariat 2011).

As already indicated in section 2.2.1, muntjac may also cause severe damage to coppice regrowth and compromise tree regeneration, but are not considered to cause browsing damage to conifers (Williams *et al.* 2010). In woodlands with high muntjac densities, new plantations need to be protected against browsing damage, the cost of which is estimated at £759 (£873 today) per hectare, in addition to the cost for protection of new trees against rabbit and other grazers (White *et al.* 2004).

Muntjac deer are also often involved in road collisions, estimated by the Deer Initiative to be about 15,000 animals/year. In England, total direct cost caused by accidents between deer and vehicles is estimated as £13.6 million, 25% of which are caused by muntjac deer. As shown in figure 7, muntjac is the most frequent species involved in deer vehicle collisions in the eastern part of England, where it is known to be especially abundant (Langbein & Putman 2006, Langbein 2007, Williams *et al.* 2010, Langbein 2011).

It has also been suggested that overabundance of muntjac deer may play a role in the transmission of diseases to cattle. However, the role of wild deer in the epidemiology and transmission of diseases to cattle are still unclear (Gibbs *et al.* 1975, Pastoret *et al.* 1988, Meyling *et al.* 1990, Delahay *et al.* 2002, Thrusfield & Fletcher 2002, Gilbert *et al.* 2005).

B/ Social impacts

Describe the expected or observed effects of the introduced species on human health and well-being, recreation activities and aesthetic values

Muntjac deer are often implicated in road traffic accidents, which is a societal concern since human deaths and injuries are often consequent to these collisions (GB Non-Native Species Secretariat 2011).

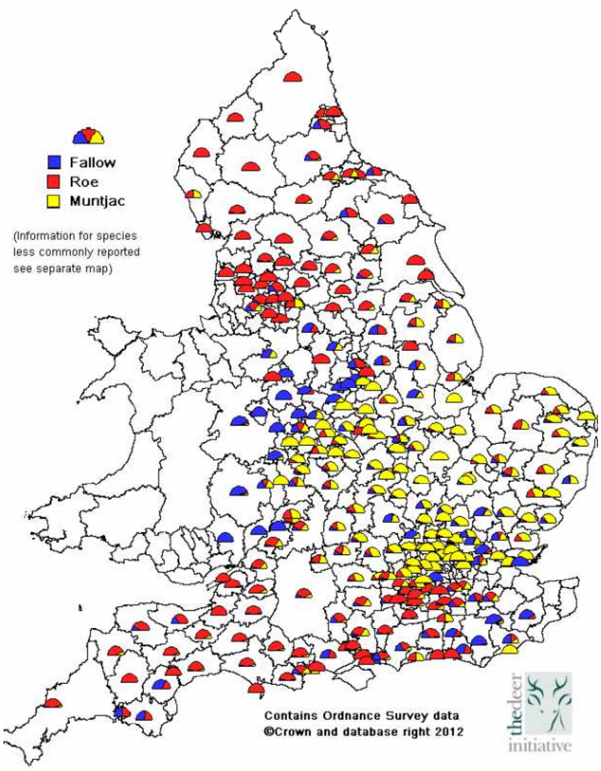


Figure 7 – Proportion of deer vehicle collisions with known species detailed reported as fallow, roe and muntjac for different districts, based on 2003-2010 data (from Langbein 2011).

STAGE 3 : RISK MANAGEMENT

The decision to be made in the risk management process will be based on the information collected during the two preceding stages, e.g. reason for initiating the process, estimation of probability of introduction and evaluation of potential consequences of introduction in Belgium. If the risk is found to be unacceptable, then possible preventive and control actions should be identified to mitigate the impact of the non-native organism and reduce the risk below an acceptable level. Specify the efficiency of potential measures for risk reduction.

3.1 RELATIVE IMPORTANCE OF PATHWAYS FOR INVASIVE SPECIES ENTRY IN BELGIUM

The relative importance of intentional and unintentional introduction pathways mediated by human activities should be compared with the natural spread of the organism. Make use e.g. of information used to answer to question 2.1.3.

The most probable pathway of muntjac entry in Belgium is by accidental escapes from captive populations or illegal deliberate releases for hunting purposes. Secondarily, a natural emigration from the Netherlands cannot be excluded providing that the Dutch feral population does reinforce and expands towards neighbouring areas.

3.2 PREVENTIVE ACTIONS

Which preventive measures have been identified to reduce the risk of introduction of the organism? Do they reduce the risk to an acceptable level and are they considered as cost-effective? Specify if the proposed measures have undesirable social or environmental consequences. Consider especially (i) the restrictions on importation and trade and (ii) the use of specific holding conditions and effect of prohibition of organism introduction into the wild.

(i) Prohibition of organism importation, trade and holding

Import and trade regulation is considered as a valuable option to limit holding, releases and escapes of muntjac deer, and reduce subsequent risks of feral population establishment. This measure can easily be justified because muntjac are regularly imported in Belgium to be kept in zoos and ornamental collections and are known to easily establish feral populations from a few individuals escaped from captive breeding sites.

Import and trade restriction measures could adequately **complement the current limitation of Muntjac holding in hobby parks based on animal welfare regulation** (Royal Decree of 16th July 2009). Indeed, this species cannot be hold by private owners as it is not included in the short positive list of mammal species. This measure should however be accompanied by a better control of its enforcement in the field and awareness raising to avoid illegal holding in private collections (J. Casaer, *pers. comm*.)

(ii) Use of specific holding conditions and effect of prohibition of organism introduction into the wild

In Belgium, the muntjac deer is not considered as a game species. It can be reared and transported only for meat production and detention in public zoos (see e.g. the regional regulation on environmental permits). No muntjac farm is currently known in Belgium. Where detention is authorized, strict holding conditions of muntjac deer should be imposed as a complementary measure to import and trade regulation. **The risk of escape from zoos and successful establishment may however be reduced through an adequate fencing, the holding of a low number of individuals per enclosure, the sterilization of captive populations, the obligation to register collections and rapidly report any escape, the frequent inspection of deer parks by public authorities and the preparation of emergency plans to remove escapees** (Carden *et al.* 2011).

The intentional and unlawful releases of muntjac deer are the most challenging to detect, monitor and control. Although their frequency could be minimized with time thanks to legislation, penalties and awareness-raising about the potential consequences of illegal releases, they cannot be completely prevented as recently observed both in United Kingdom and Ireland. **The use of ear tagging system for importing and holding muntjac deer and associated penalties when tagged animals are found in the wild could be used as a good incentive to reduce both intentional and accidental releases** (Chapman *et al.* 1994, Carden *et al.* 2011, Ward & Lees 2011).

Belgian regional nature conservation legislation strictly prohibits intentional release of muntjac deer into the wild as for other non-native species. In spite of current legal instruments, those events cannot be completely prevented.

3.3 CONTROL AND ERADICATION ACTIONS

Which management measures have been identified to reduce the risk of introduction of the organism? Do they reduce the risk to an acceptable level and are they considered as cost-effective? Specify if the proposed measures have undesirable social or environmental consequences. Consider especially the following questions

(i) Can the species be easily detected at early stages of invasion (early detection)?

Muntjac deer are difficult to observe directly and to detect at early stages of invasion because they are small-sized, have secretive habitats and occupy dense vegetation. Most of the time, they are not detected in an area before having already reached a high density or are reported as consequence of traffic-collisions. To be efficient, early detection will need setting up active surveillance through a dedicated network of trained field observers (incl. hunters, naturalists, foresters, road managers, etc.), rapid reporting of muntjac sightings and confirmation of muntjac presence using baited camera traps sites in woodlands (Hemami *et al.* 2005, Putman 2009, Ward & Lees 2011).

(ii) Are they some best practices available for organism local eradication?

Best practices for muntjac eradication and culling have been published by different governmental and hunting organizations from England, Wales and Scotland (see e.g. Smith-Jones 2004, The deer initiative 2008, Ward & Lees 2011). Collaborative intensive culling by groups of professional stalkers associated with accurate population survey is identified as one effective technique, providing that appropriate techniques are used and stalkers are adequately trained. Indeed, experienced deer stalkers are often reported failing to shoot muntjac because search image and stalking tactics are inappropriate for this species. Culling must imperatively be prolonged until the last muntjac has been killed to avoid population re-establishment. Trapping might also present a cost-effective option to complement culling and ensure complete eradication (figure 8). However, trapping becomes very difficult at the end of eradication programs and requires high commitment (J. Casaer, *pers. comm.*). As for all other animal control measures, adequate trapping techniques need to be adopted to the species and the local circumstances to be cost-effective and to address ethical and welfare considerations (Chapman *et al.* 1987, Putman 1995).

Figure 8– Two muntjac feeding on maize bait in a corral trap. Image taken by a Reconyx RC60 digital trail camera (Ward & Lees 2011)

(iii) Do eradication and control actions cause undesirable consequences on non-target species and on ecosystem services?

The period for shooting muntjac has to be adapted to reduce disturbance to other animal species. There also can be a negative interaction with the possibility to hunt other species, given the fact that the needed hunting pressure can also induce shyness of other game species (Jim Casaer, *pers. comm.*). Trapping, being less disturbing for other game and non-game species, will inevitably lead to the capture of non-target animal species.

(iv) Could the species be effectively eradicated at early stage of invasion?

Where establishment of populations is comparatively recent and populations are still small and localized, a local eradication of individual population nuclei before further expansion is theoretically feasible (Putman 2009). However, **no example of a successful local muntjac eradication is available so far and this operation is considered as resource demanding**. Ward & Lees (2011) estimated that the costs of eradicating an outbreak of 200 animals were likely to range from £16,450 to £60,625, including subsistence and travel costs of staff.

Muntjac eradication has also been proved to be difficult to put in place in England because of preferences exhibited by this species for peri-urban situations. Deer culling was shown to be hardly performed in those areas because of hunting limitations and public opposition to lethal control methods, especially when damages are still limited. It means that awareness and education are important prerequisites to improve the public acceptance of control actions (Chapman *et al.* 1994, Bermner & Park 2007, Carden *et al*. 2011, Dandy *et al.* 2011).

Muntjac deer is neither a protected species nor a game species in Belgium. In Wallonia and in Flanders, culling by hunters, private owners and foresters is allowed during the whole year, providing that a hunting permit is held (see e.g. the ministerial guideline n°2688 on the control of non-native animal species in Wallonia).

(v) If widely widespread, can the species be easily contained in a given area or limited under an acceptable population level?

When widely established, eradication of muntjac deer is probably impossible to reach even if it is desirable. Muntjac culling to reduce densities below critical damage thresholds is a possible option that has been adopted in some forested areas of England, like the Monks Wood National Nature Reserve. Moderate culling each year has been shown to be more efficient than occasional intensive culling to reduce population density. **It is however very difficult to over-shoot a muntjac population and the global efficiency of mitigation measures adopted in England is usually considered as moderate.** The experience from England is that annual muntjac culls do steadily increase year after year despite unrestricted culling. This is also a very costly operation: it has been estimated that managing an established muntjac population in perpetuity in Scotland could range from £457,821 to £1,915,411 per year. Muntjac containment is also a difficult target to reach. In case of establishment and expansion of a muntjac population in the Netherlands, the maintenance of "cordons sanitaires" against its expansion in Belgium is likely to cost a lot of resources (Harris *et al.* 1995, Cooke 2003 & 2004, Smith-Jones 2004, GB non-native species secretariat 2011, Ward & Lees 2011).

When dealing with non-professional hunters as is the case in Belgium, the involvement of the hunters in a eradication of containment program for muntjac will only be successful if the management goal is supported by the hunters participating in the program. This can require further awareness raising and education and require a bounty system or cost-sharing between the different organizations and persons involved in the program (J. Casaer, *comm. pers*.)

CONCLUSION OF THE RISK MANAGEMENT SECTION

Establishment of muntjac deer due to escape from captive populations hold in deer parks, ornamental collections or zoos may occur in Belgium in the coming years and is considered as more likely than an expansion from existing populations in neighbouring countries. The prohibition of its importation and trade and the strengthening of the holding interdiction together with awareness raising could therefore be considered as efficient measures for reducing the risk of establishment to an acceptable level.

Where deer parks are already present and have to be maintained (e.g. in public zoos), escape and establishment risk should be reduced through the adoption of drastic security measures including ear-tagging and systematic sterilization of captive deer combined with the obligation to register existing collections and to rapidly report any escape.

Those preventive measures have to be preferred over early detection and population control as the muntjac deer may easily establish feral populations after escape. It is a very discreet animal that is difficult to detect and to cull. So far, no muntjac population has been extirpated through eradication actions. Successful density control and containment are difficult to achieve and cannot be reached without the collaboration of all landowners, and without a good, intensive and coordinated approach involving well trained hunters that are sharing the management goal and are consequently willing to contribute actively to a significant reduction or to the containment of the local muntjac populations. A further awareness raising among the hunting community and education on the possible negative consequences of the presence of the species will be essential to reach this purpose.

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http://biodiversite.wallonie.be/invasives
Email : invasives@spw.wallonie.be

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