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The current status of the raccoon (*Procyon lotor*) and the raccoon dog (*Nyctereutes procyonoides*) in Austria

Key words: Raccoon, *Procyon lotor*, Raccoon dog, *Nyctereutes procyonoides*, Austria, distribution, population density

Introduction

The north-American raccoon (*Procyon lotor*) as well as the east-Asiatic raccoon dog (*Nyctereutes procyonoides*) were introduced to Europe during the first half of the 20th century (LUTZ 1984; NOWAK 1973; STUBBE 1975). In those days these medium-sized carnivores were important goods for the influential fur industries. As a result, up to several thousand individuals of these highly adaptable generalists were set free in various parts of Europe. The free ranging populations of both species did well and increased their distribution ranges (KAUHALA 1996). Spreading throughout Europe (BARTOSZEWICZ, M. 2011; KAUHALA and KOWALCZYK 2011), in some countries, raccoons and raccoon dogs have even become the most common carnivore species (KOWALCZYK 2014). As invasive alien species (IAS) they are supposed to have significant environmental, economic and public health impacts (GENOVESI and SHINE 2003). Consequently, monitoring of IAS is an actual topic in wildlife ecology, even more so since its implementation has been determined by European legislation as of 2015 (EU Regulation No 1143/2014).

The first evidence of raccoon immigration to Austria was a single raccoon trapped in the direct vicinity of the Austrian-German border in Salzburg (Oberndorf, district Salzburg surroundings; AUBRECHT 1985) in 1974. Isolated records from different parts of Lower Austria in 1930 (SACKL 2001b), 1972 and thereafter (AUBRECHT 1985), as well as from Tyrol in 1993 were supposed to have been caused by exposed or escaped raccoons that complemented the immigrants from the northwest (AUBRECHT 1995).

Raccoon dogs have been reported from the north-eastern parts of Austria since 1963. BAUER (1986) published a list of these unproven records as well as the first records based on scientific evidence dating from 1983 (Mannshalm, district Zwettl, Lower Austria) and 1984 (Auersthal, district Gaenserndorf, Lower Austria). It can thus be concluded that the raccoon dog is immigrating from the northeast. In the following decades, more recent records of raccoons and raccoon dogs were published by AUBRECHT (1995) and SACKL (2001a, 2001b) and revealed a slight increase in their spread. Both species are huntable in all Austrian provinces but lacking a consistent nationwide documentation of bag re-

cords. As a result, little is known about the current status of the raccoon and the raccoon dog in Austria, but both of these invasive species are assumed to be a potential risk for Austrian native fauna (ESSL and RABITSCH 2002). The present study was aimed at a) identifying the current distribution ranges of raccoon and raccoon dog in Austria and b) estimating their population densities (in example areas).

Material and Methods

Identification of distribution ranges

I started to collect raccoon and raccoon dog records from the provincial museums and the Museum of Natural History as well as from the Hunting Association of each province in 2009. In addition, I sent questionnaires to the officials of the Provincial Hunting Associations in every district and to zoological preparators throughout Austria and collected further data with the help of an online questionnaire. To support this survey I engaged in public relations by giving talks and interviews, writing articles and creating a project web site (www.enok.at). Every record and its corresponding location were documented within an ArcGIS 10.1 (©ESRI) database. I then differentiated the records using the following categories:

Table 1 Categorization of collected records

category		description
1		proven records: picture of an animal, its carcass or preparation or tissue samples
2		pictures of tracks
3a	sightings	reports of animals shot or trapped or found dead (without proof)
3b		sightings by experts (without proof)
3c		sightings (without proof)
4		records of obvious pets (with or without proof)

Estimation of population densities in example areas

Research areas

The estimation of the population densities of the raccoon and the raccoon dog was conducted from February 2012 until October 2012 in the Thaya Valley and from February 2012 until February 2013 in the Donau-Auen National Park. These locations were chosen as research areas due to the following criteria: 1) the habitat was assumed to be suitable for both study species; 2) there were former records (or at least sightings) of both species in these areas or in their direct surroundings; 3) a connected area of adequate size was available; 4) local help was offered by project partners within the research areas and 5) the driving distance into the research area was acceptable. Donau-Auen National Park is characterised by the floodplain areas of the river Danube. It is located in the east of Vienna and extends up to the Austrian-Slovakian border. In its area of 9300 hectares of size it harbours many different and sometimes rare habitats that have developed due to the periodical floodings. The river Thaya in the north of Lower Austria formed a canyon-like valley in the rocks of the Bohemian Massif. 25 kilometres of its natural length are defining a part of the border between Austria and Czech Republic. This exceptionally well-preserved example of a river valley landscape is protected by the help of national parks on both sides of the border, covering an area of 1330 hectares on the Austrian side and 6260 hectares on the Czech side.

Capture – mark - re-capture

In each of the two research areas eight trapping places were chosen due to habitat characteristics. These trapping places needed to be near water (riversides, ditches or ponds with vegetation cover) or in wetlands (marshes, reed areas) offering structure elements (e. g. hedges). Furthermore, they needed to be easily accessible in order to assure regular baiting with fish and dry cat food, as well as fast access in case of trapping events. The distance between two trapping sides was 2 to 3 km and thus comparable to the

radius of a medium sized raccoon or raccoon dog home range. I installed a cage trap and at least one camera trap (Cuddeback Capture with flashlight, occasionally additional infrared cameras: Minox DTC 600) facing the trap entrance at each trapping site. Thus the camera trap was triggered both by animals in as well as in front of the trap. To enable selective trapping of raccoons or raccoon dogs, the traps were activated only if the occurrence of these goal species was already proven by camera trap pictures. A trapped raccoon or raccoon dog was secured with the help of a handling cage and marked with coloured ear tags (Fa. Dalton) printed with an individual number and with the project web site. An individual composition of ear tag colours should lead to recognition of the marked individual when re-trapped with a cage trap or by the help of camera traps (compare MICHLER et al. 2008).

The proportion of trapped (and marked) individuals (x) in a population (n) of wildlife species can be assumed to be the same as the proportion of marked individuals (m) in all individuals trapped at a second event (y): $m/y = x/n$ (AMSTRUP et al. 2005). Thus the population size can be estimated using the following formula: $n = x*y/m$. Based on this assumption the population sizes of the raccoon and the raccoon dog in this study were determined using the program MARK (© Gary White).

Results

Identification of distribution ranges

Within the present study I collected 149 raccoon records and 121 raccoon dog records. Only 7 of the raccoon records and 5 of the raccoon dog records were reported from a time period before 2000. In case of the raccoon, 46 of the records (31 %) were documented with photographs or carcasses (Tab. 2). Only two of the six documented tracks (4 % of all records) could clearly be identified as raccoon tracks. The other four track pictures were either of low quality and/or lacked indication of size. The 93 raccoon sightings were differentiated into three categories reflecting decreasing certainty: 22 (15 %) reports of raccoons trapped or shot or found dead, 24 (16 %) sightings of living animals by

experts (biologists, hunters etc.) and 47 (31 %) sightings of living animals by other observers. Furthermore, four raccoon records were identified as obviously escaped pets (or zoo animals). Concerning the raccoon dog records, 48 (40 %) were proven by photographs or carcasses/tissue samples (category 1, Tab. 2). None of the 8 documented tracks could clearly be verified as raccoon dog tracks due to low photograph quality, missing size indication or misleading substrate (e. g. old snow). Moreover, 65 unproven sightings of raccoon dogs were reported: 27 (22 %) sightings of dead individuals (shot or trapped or found dead), 18 (15 %) sightings by experts and 20 (16 %) by non-experts.

Table 2 Number of raccoon and raccoon dog records of each category

category	description		raccoon records	raccoon dog records
1	proven record		46	48
2	track		6	8
3a	sighting	of dead ind.	22	27
3b		by expert	24	18
3c			47	20
4	pet		4	0
sum	-		149	121

Distribution of the raccoon in Austria

The highest percentage of raccoon records were reported from the northern provinces: 37 % from Upper Austria, 19% from Lower Austria, 12 % from Salzburg and 10 % from Vienna. Only 9 % of the raccoon records were reported from Styria and less than 5 % from the other provinces (Burgenland, Carinthia, Tyrol and Vorarlberg). It can thus be concluded that raccoons occur in the whole pre-alpine region and the Austrian part of the Bohemian Massif with reports cumulating in the following regions: the Upper Austrian Danube Valley, the Muehlviertel and the Enns and Steyr Valley, the eastern floodplain areas of the Danube as well as the Rhine valley in the very west of Austria

(Fig. 1). There are also clusters of records in the vicinity of bigger cities: Linz, Salzburg, Graz, Vienna and Innsbruck – albeit only sightings (without evidence) have been reported from the two last ones so far.

The 35 raccoon records from alpine regions were mainly from lower altitudes within the Alps (valleys and basins): Windischgarsten Basin (3 proven records), Salzach Valley, Inn Valley, Mur and Liesing Valley (1 proven record), Drau Valley and Klagenfurt Basin (2 proven records). All these raccoon records were documented from locations with an elevation of less than 1000m above sea level, with the exception of one male raccoon that was killed by a snowmobile in February 2010 at approximately 1700m above sea level (Obersulzbach Valley, district Zell am See). This individual was documented by photographs and tissue samples and there is no indication that this raccoon was a pet or a zoo animal.

The first evidence of raccoon reproduction in the year 1978 was from the Tullnerfeld region (Aubrecht 1985). Within this project, sightings of juvenile raccoons were reported from Lower Austria and Upper Austria in the years 2005, 2008 and 2009. There is further proof of juveniles and hence of racoon reproduction in 2014 (district Neunkirchen; Lower Austria) and in 2015 (district Salzburg surroundings; Salzburg).

Distribution of the raccoon dog in Austria

The raccoon dog records were mainly reported from the north-eastern provinces: 32 % from Lower Austria, 29% from Upper Austria, 12 % from Burgenland as well as from Styria. Only 7 % of the raccoon dog records were reported from Salzburg and less than 5 % from the provinces Carinthia, Tyrol, Vorarlberg and Vienna. The data show that the raccoon dog currently mainly occurs in the northern and eastern parts of Austria with some proven records (category 1) from the southeast (Fig. 2). Additionally there is one proven record from the Klagenfurt Basin (2015) in the very south of Austria and another one from the Bregenz Forest (2014) in the west. Nevertheless, no proven record has been reported from alpine terrain and only a fractional amount of unproven records (11 sightings and 2 tracks) were located in inner alpine regions. These were reported from lower altitudes within the Alps: Windischgarsten Basin, Enns Valley, Muerz and Mur Valley, Klagenfurt Basin, Drau Valley and Inn Valley.

Within this study the first proven records of juvenile raccoon dogs in Austria were documented in north-eastern Austria in 2011 (district Gmünd, Lower Austria) and 2014 (district Gaenserndorf and district Bruck/Leitha, Lower Austria). Moreover, juvenile sightings were reported from Lower Austria and Upper Austria in the years 2010 and 2011.

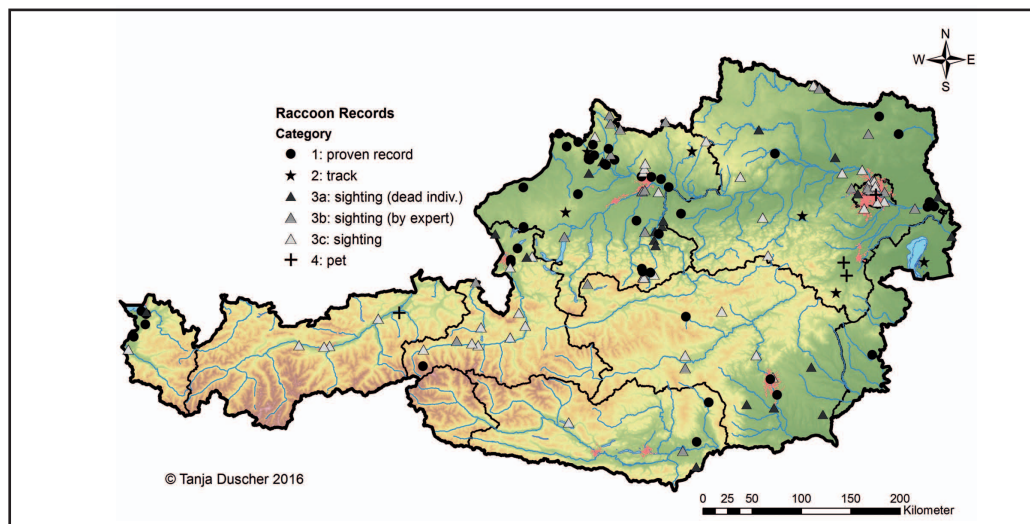


Fig. 1 Geographical distribution of the categorized raccoon records in Austria

Estimation of population densities in example areas

Altogether 1078 photographs of the installed camera traps were evaluable, 526 from Donau-Auen and 552 from Thaya Valley (Tab. 3). In both research areas more than 30 % each of the animals triggering the camera were red foxes (*Vulpes vulpes*; 36,3 % in Donau-Auen and 32,4 % in Thaya Valley) and wild boar (*Sus scrofa*; 31,4 % in Donau-Auen and 33,7 % in Thaya Valley). These seem to be the most common game species in both regions. A considerable amount of photographs showed other common species of the research areas, such as badger (*Meles meles*, 6,1 %) and red deer (*Cervus elaphus*, 8,4 %) in the Donau-Auen, otter (*Lutra lutra*, 8,5 %) in Thaya Valley and roe deer (*Capreolus capreolus*; 7,4 % and 11,8 %) in both areas. Some of the more rarely documented species in the research area Donau-Auen were: *Lutra lutra*, *Mustela putorius*, *Martes spp.*, *Dama dama*, *Lepus europaeus*, *Castor fiber*, *Rattus spp.*, *Sciurus vulgaris*, *Ciconia nigra*, *Strix aluco*, *Buteo buteo*, unspecified carnivores, unspecified passeriformes as well as domestic dog, domestic cat and human. For the research area Thaya Valley the following species could be documented by photographs less frequently: *Meles meles*, *Mustela erminea*, *Martes spp.*, *Cervus elaphus*, *Lepus europaeus*,

Table 3 Number and percentage of pictures of each species detected in the research areas Donau-Auen and Thaya Valley

	Donau-Auen	%	Thaya Valley	%
human	3	0,6	15	2,7
<i>Vulpes vulpes</i>	191	36,3	179	32,4
<i>Meles meles</i>	32	6,1	12	2,2
<i>Lutra lutra</i>	1	0,2	47	8,5
<i>Mustela erminea</i>	0	0	5	0,9
<i>Mustela putorius</i>	10	1,9	0	0
<i>Martes spp.</i>	6	1,1	18	3,3
domestic dog	1	0,2	5	0,9
domestic cat	1	0,2	0	0
carnivora, unspecified	1	0,2	7	1,3
<i>Sus scrofa</i>	165	31,4	186	33,7
<i>Capreolus capreolus</i>	39	7,4	65	11,8
<i>Cervus elaphus</i>	44	8,4	2	0,4
<i>Dama dama</i>	1	0,2	0	0
<i>Lepus europaeus</i>	6	1,1	11	2
<i>Castor fiber</i>	2	0,4	0	0
<i>Rattus spp.</i>	1	0,2	0	0
<i>Sciurus vulgaris</i>	6	1,1	0	0
<i>Ciconia nigra</i>	2	0,4	0	0
<i>Strix aluco</i>	1	0,2	0	0
<i>Buteo buteo</i>	5	1	0	0
passeriformes, unspecified	8	1,5	0	0
sum	526	100	552	100

unspecified carnivores as well as domestic dog and human.

In both research areas no camera trap picture of raccoons or raccoon dogs was taken in the course of the field work of this project. It was consequently impossible to estimate the population density of these species in the chosen example areas.

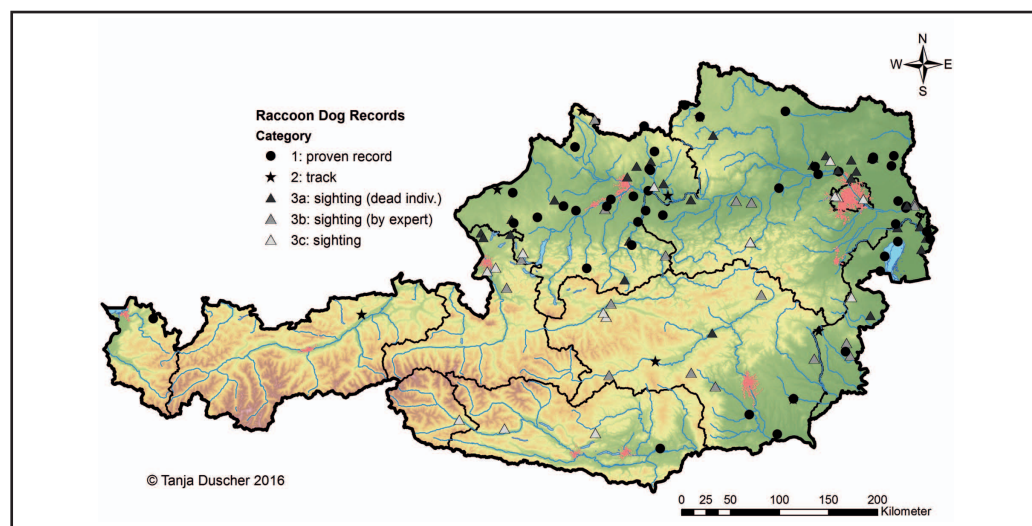


Fig. 2 Geographical distribution of the categorised records of the raccoon dog in Austria

Discussion

Distribution of the raccoon and the raccoon dog

The distribution of the raccoon and the raccoon dog documented within this study generally reflects the findings of previous publications (AUBRECHT 1985 and 1995, BAUER 1986, SACKL 2001a, 2001b) concerning immigration pathways and early invaded regions and confirms the assumptions of AUBRECHT (1995) that raccoons will extend their range towards the southeast and raccoon dogs will spread to the south and to the west. Accordingly, both species are currently widely distributed throughout Austria, particularly in the pre-alpine regions. The largest amount of proven raccoon records were reported from the Salzburg and Upper Austrian Pre-Alps in the north with some evidence from the Pannonian lowlands in the east, the south-eastern Pre-Alps as well as from the Rhine Valley in the west of Austria. In contrast, the raccoon dog records are distributed more continuously in the Upper Austrian and Lower Austrian Pre-Alps including the Bohemian Massif and the Pannonian Lowlands with a smaller percentage from the south-eastern Pre-Alps (Carpathian outlands) and only one record from the west of Austria. This raccoon dog male in the Bregenz Forest (2014) seemed to immigrate from the German Allgaeu region in the north.

Alpine situation

The alpine regions seem to be less influenced by the immigration of these two non-indigenous carnivore species. Only one single proven record of a male raccoon could successfully be documented from alpine terrain. Additionally, some raccoon sightings were reported from river valleys or basins in the Alps. Although false reports can never be excluded among reported sightings, the categorization used in this study helps to assess the certainty of the records. In case of the raccoon, the category 4 records (pets) indicate a potential problem with private keeping of raccoons in Vienna and in the district Neunkirchen (southwest Lower Austria). What is more, based on information from lo-

cal hunters, I hypothesise that the records from the Windischgarsten Basin at least partly originated from offspring of raccoons escaped from a wildlife park. In contrast there is no indication to assume that the alpine raccoon evidence from Obersulzbach Valley (2010, 1700 m above sea level) is based on an escaped raccoon, comparable to the Tyrolean record from 1993 (AUBRECHT 1995). Furthermore, several unproven sightings documented by the local natural history museum of Salzburg (compare STÜBER et al. 2014) indicate a colonisation along the Salzach Valley. The raccoon dog seems to avoid higher elevated habitats even more than the raccoon (DUSCHER and NOPP-MAYR in prep.). Only two uncertain tracks were reported from alpine areas apart from some sightings along alpine valleys. The credibility of these records has to be questioned. Nevertheless, unproven records can be seen as indicators of newly colonized areas.

Population densities of the raccoon and the raccoon dog

Not only the geographical range of reports has increased since the publications of AUBRECHT (1995) and SACKL (2001a, 2001b), but also their frequency with a mean of 15 raccoon records and 13 raccoon dog records per year (between 2009 and 2015). However, the frequency of reports does not necessarily reflect the realistic raccoon or raccoon dog abundance, since it can be influenced by several other factors: (1) differences in observer density, (2) regional differences in communication networks, (3) different intensities of public relations, (4) differences in the documentation of bag records due to varying provincial hunting laws. Therefore the population density should have been estimated in example areas by a capture-mark-re-capture study. Unfortunately, in both study areas, Donau-Auen as well as Thaya Valley, raccoons or raccoon dogs could neither be trapped and marked nor documented by camera traps during the study period. This can partially be explained by methodological problems since 1) the choice of trapping sites was a compromise between optimal habitat and accessibility, 2) the baiting could not be done every day and not always by the same person, 3) mouse den-

sity was extremely high during the fieldworks due to a full harvest of acorn and beech nut in the former autumn, presumably making the bait less attractive and 4) there were some gaps in the documentation as sometimes the need to change camera trap batteries remained unnoticed for several days.

Nevertheless, the results of the camera trap monitoring seem to represent a realistic composition of wildlife species occurring in both study areas, with herbivore species being underrepresented since these would not have been attracted by the bait. The occurrence of raccoons and raccoon dogs was previously reported from the study regions (AUBRECHT 1995; SACKL 2001a, 2001b), but their population densities still seem to remain on a low level. Those few individuals that may live in the highly structured areas of Donau-Auen and Thaya Valley are obviously using some optimal but hidden habitat edges and have consequently not been detected. Furthermore, the Austrian bag statistics of the former decade show a maximum of 31 raccoons and 52 raccoon dogs shot or trapped and documented annually (Fig. 3). Since in some Austrian provinces raccoons or

raccoon dogs shot or trapped are not automatically registered according to species but filed under „other animals“, these data are currently not available for the whole country, still they provide a certain indication of the population levels and developments.

Prospects

Population densities of the raccoon and the raccoon dog in Austria are currently low in comparison to neighbouring countries invaded by these carnivore species. It is however very typical for biological invasions to begin very slowly with a delayed rapid area expansion (CROOKS and SOULE 1996). Correspondingly, population densities of these new game species remained low in Germany for three to six decades until they suddenly increased in the middle of the 1990s (NUY and SCHMITZ 2014). Since raccoons and raccoon dogs are by now broadly distributed in Austria and the lowland habitats seem to be suitable for both species (DUSCHER and NOPP-MAYR in prep.), a population increase of these non-indigenous species can be expected.

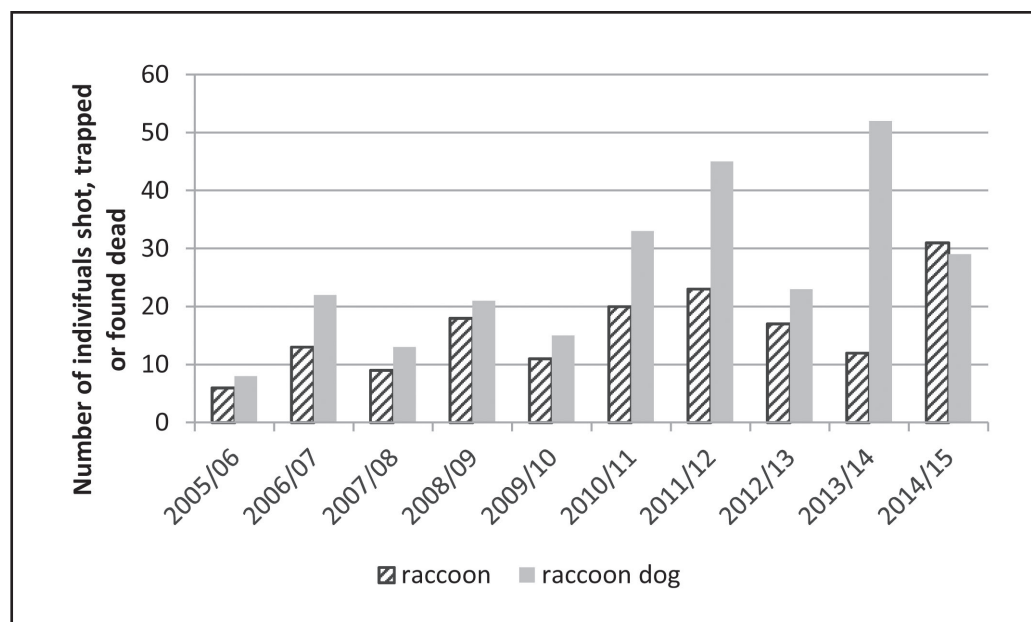


Fig. 3 Sum of raccoon and raccoon dog hunting bags from 2005/06 to 2014/15 from the provinces Salzburg, Upper Austria, Lower Austria, Styria and Carinthia (provided by the Hunting Associations)

ted in the coming decades. Facing this probable population development, a continuous nationwide monitoring (e. g. obligatory recording of bag statistics) of these invasive alien species should be a priority objective according to the new EU regulation (1143/2014).

Abstract

The non-indigenous carnivore species raccoon (*Procyon lotor*) and raccoon dog (*Nyctereutes procyonoides*) have been proven to occur in Austria since 1974 and 1983 respectively. Within the present study 149 raccoon records and 121 raccoon dog records of different categories were documented since 2009. These records show a broad distribution of both species in Austria, particularly in the lowlands and river valleys. An estimation of their population densities in example areas failed due to their evidently low abundance. Comparably low population densities are also indicated by hunting bag data of several Austrian provinces. Nevertheless, a population increase has to be expected within the coming decades. Hopefully, the results of this study will contribute to establish a continuous nationwide monitoring of these (and other) invasive alien species.

Zusammenfassung

Die gebietsfremden Raubsäugerarten Waschbär (*Procyon lotor*) und Marderhund (*Nyctereutes procyonoides*) wurden in Österreich erstmals 1974 bzw. 1983 nachgewiesen. Seit 2009 wurden im Rahmen der vorliegenden Studie 149 Waschbär-Nachweise und 121 Marderhund-Nachweise verschiedener Kategorien dokumentiert. Anhand dieser Nachweise lässt sich eine großflächige Verbreitung beider Arten in Österreich erkennen, mit einem Schwerpunkt in den Niederungen und Flusstäler. Eine Populationsdichteschätzung von Waschbär und Marderhund in Beispielgebieten blieb aufgrund ihrer offensichtlich geringen Dichte ergebnislos. Auch die Jagd-Statistiken aus einzelnen Bundesländern geben einen Hinweis auf vergleichsweise geringe Bestandesdichten dieser Wildarten. Ein Anstieg der Populationsdichten

von Waschbär und Marderhund in den kommenden Jahrzehnten ist jedoch zu erwarten. Es wäre wünschenswert, wenn die Ergebnisse dieser Studie zur Etablierung eines kontinuierlichen österreichweiten Monitorings dieser (und anderer) invasiver gebietsfremder Arten beitragen.

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