Use of water troughs by wild rabbits (*Oryctolagus cuniculus*) in a farmland area of north–west Spain

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Abstract

Use of water troughs by wild rabbits (*Oryctolagus cuniculus*) in a farmland area of north–west Spain.— Installation of water troughs is a common approach to increase densities of small game species in the Iberian peninsula but little is known about the watering patterns of target species, such as the wild rabbit (*Oryctolagus cuniculus*). Using camera trapping, we monitored the use of water troughs by wild rabbits over 228 weeks in three consecutive periods, from June to October in 2008, 2009 and 2010, on farmland in north–west Spain. Wild rabbits used 43 % of the water troughs. A significantly higher number of rabbits were observed drinking at troughs surrounded by shrub cover than at those in open fields. Most drinking events were recorded from July to September (98 %), though the use of water troughs was not clearly related to weather. Wild rabbits drank mainly during the morning (52 % of rabbits), less so in the evening and at night, and rarely in the afternoon. Wild rabbits were photographed together with red–legged partridges (*Alectoris rufa*) in 6 % of photographs. These findings suggest water troughs are useful for species such as wild rabbits and should be allocated close to shrub areas.

Key words: Camera traps, Cover, Game management, Water trough, Wild rabbit

Resumen

Uso de bebederos por parte del conejo de monte (*Oryctolagus cuniculus*) en un paisaje agrícola en el noroeste de España.— En la península Ibérica, los bebederos son una herramienta de gestión de hábitat muy frecuente para incrementar las densidades de especies de caza menor, aunque el comportamiento de ingestión de agua de las especies “diana” no se ha estudiado en profundidad, como es el caso del conejo de monte (*Oryctolagus cuniculus*). Estudiamos el uso de bebederos por parte de conejos de monte durante 228 períodos de una semana en tres periodos consecutivos (junio–octubre) de 2008, 2009 y 2010 en un paisaje agrícola de noroeste de España, utilizando cámaras de fototrampeo. Los conejos utilizaron el 43 % de los bebederos y se observó un número significativamente mayor de conejos bebiendo en bebederos rodeados por cobertura vegetal en comparación con bebederos situados en campos abiertos sin dicha cobertura vegetal. La mayoría de los conejos que bebieron fueron fotografiados de julio a septiembre (98 %), si bien la utilización de bebederos no se relacionó claramente con la climatología. Los conejos bebieron principalmente durante la mañana (52 % de los conejos) no tanto durante la tarde y noche, y raramente durante el mediodía. Los conejos se fotografiaron junto con perdices rojas (*Alectoris rufa*) en el 6 % de las fotografías. Estos hallazgos sugieren que los bebederos son útiles para el conejo y otras especies con necesidades hídricas similares y que debieran ser colocados cerca de zonas con cobertura vegetal arbustiva.

Palabras clave: Cámaras de fototrampeo, Cobertura vegetal, Gestión cinegética, Bebedero, Conejo de monte

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Introduction

During the last decades, considerable efforts have been made in the Iberian Peninsula to improve the management of small game species. These animals play a key role in ecosystems and hunting such species is a crucial economic activity in many rural areas (Arroyo et al., 2012; Ferreira et al., 2014). One of the most commonly used approaches to preserve populations of small game species in Spain is the installation of water troughs (Arroyo et al., 2012; Ferreira et al., 2014), defined as free–standing water supplied artificially for wildlife. One key–stone species in the Mediterranean Basin is the wild rabbit (Oryctolagus cuniculus, hereafter rabbit), (Delibes–Mateos et al., 2008). Although rabbits can endure extended periods of drought (Hayward, 1961; Cooke, 1982) and distance to drinking water does not seem to affect their abundance in any season in Central Spain (Rueda et al., 2008), their reproduction has been correlated with environmental temperature and water content of the vegetation (Gonçalves et al., 2002). Furthermore, many gamekeepers and wildlife managers claim that rabbits frequently use water troughs when water is scarce. In the past, water troughs mainly targeted red–legged partridge (Alectoris rufa) populations and they were not aimed at rabbits as water availability is not generally considered a major constraint for this species (Hayward, 1961). However, in their study about the frequency of use and cost–effectiveness of habitat management techniques in rabbit populations in Iberia, Ferreira et al. (2014) found that water troughs also targeted rabbits. They suggested that supplying water would maximise returns from a set budget.

Studies in the red–legged partridge have shown that water troughs surrounded by shrub cover are used to a greater extent than those in open fields. It has also been observed that weather plays a role, with a higher number of visits to troughs in summer months (Sánchez–García et al., 2012a).

A better understanding of rabbit watering patterns could optimize the installation and use of water troughs, not only for the benefit of endangered predators that rely on rabbits, such as the Iberian lynx (Lynx pardinus) (Ferreira et al., 2010), but also for reared rabbits released for both hunting and conservation purposes (Sánchez–García et al., 2012a).

Aiming to produce guidelines for best watering practices for small game species, we evaluated the use of water troughs by rabbits to (1) confirm their use by this species, (2) to investigate the effects of trough location in shrub cover or open fields on use by rabbits, (3) to assess whether drinking behaviour is affected by weather, and (4) to study the daily watering patterns of the species.

Material and methods

Study area

This study was conducted from late spring to early autumn (June–October) over three consecutive years (2008/09/10) on private farmland of 308 ha in the province of Valladolid in north–west Spain (lat 41° 53’ 45” N, long 4° 52’ 50” W, ‘Finca Coto Bajo de Matallana’). The area is a typical pseudo–steppe of northern Spain with mostly flat terrain (altitude range 771–820 m a.s.l.). The climate is dry Continental Mediterranean, characterized by harsh winters and hot and dry summers, with an annual mean rainfall of 455 mm (AEMT, 2014). Historically, extended periods of drought have been recorded in the area from June to September. The study area has two small streams but these dry up in summer months and only flow after occasional storms.

Shrub areas accounted for 38% of the area, cultivated fields for 37%, arboreal plants for 23%, and the remaining 2% for uncultivated areas, farm buildings and tracks. The main cultivated species were sunflowers (Helianthus annuus), lucerne (Medicago sativa) and winter cereal (mainly barley, Hordeum distichon).

Game management

The area was actively managed for small game densities and other wildlife from 1996 to 2008. A full time gamekeeper was employed and hunting was not allowed. Legal control of predators was conducted all year round following regional law —especially during the game bird breeding season (February–May)— and included magpies (Pica pica, L.), carrion crows, (Corvus corone L.), foxes (Vulpes vulpes, L.), feral dogs (Canis lupus familiaris, L.) and cats (Felis catus, L.), and brown rats (Rattus norvegicus, L.). Fifteen strips of mixes of barley, wheat (Triticum spp. L.), lucerne and common vetch (Vicia sativa L.) (0.2 ha average size), were distributed throughout the area. Management practices included the restricted use of herbicides, no livestock grazing at potential nesting habitats for farmland birds, and harvesting delays until early June and only in daytime. Additionally, 16 feeding troughs with wheat grain were distributed every 15–20 ha in autumn and winter.

Due to repeated outbreaks of myxomatosis and rabbit haemorrhagic disease, numbers of rabbits were dramatically reduced in late 1980s (Olmedo, pers. comm.). A re–establishment programme was carried out from 1996 to 2002, using translocated rabbits established in artificial warrens (Diez, 2005; Fernández–Olalla et al., 2010). In 2008, 27 active warrens were detected and rabbits occupied 70% of the study site. Using the Kelker method, rabbit density (rabbits/ha) was estimated at 2.1 in 2008, 3.4 in 2009 and 1.36 in 2010 (Lacasa et al., 2010).

Experimental design

We used the methodology established in a previous project on water troughs for small game species (Lacasa et al., 2010). Water was supplied from a fibre cement water tank connected to the concrete water troughs by means of plastic pipes. The tank was refilled at the beginning of each summer (400 l of capacity). All troughs were surrounded by a 1.5 m
high metal fence with 20 cm² entrances, a design shown to have no effect on use by small game species (Lacasa et al., 2010) (fig. 1). For practical reasons, the location of troughs was not changed during the study periods. The estimated cost of the water supply, not including maintenance, was 3.5 €/ha/year.

We studied five pairs of water troughs (total 10 troughs), located in five plots of 50–60 ha. All troughs were placed at a minimum distance of 500 m from the streams. Aiming to assess whether shrubs surrounding water troughs had any effect on the number of rabbits using them, in each plot we placed one of the water troughs among shrub cover (referred to as protected troughs) and the other at a distance of 50 m in an open field (referred to as open troughs), not surrounded by shrub cover. At the protected troughs, the shrubs were kept at a distance of 3–5 m. Average shrub and tree height across plots was 2.2 m ± 0.8 SE. Specific species were brambles (Rubus spp.), broom (Cytisus spp.) and pine trees (Pinus spp.).

To assess the effects of weather on weekly drinking patterns of rabbits, data collection was carried out from June 15th to October 10th of each study year. Based on data from an on-site weather station (Urbaso S.L., Spain), this was the driest period of the year, with limited rainfall. Maximum temperatures were above 35ºC, and relative humidity was under 60%, though conditions were hottest and driest in July and August.

The water troughs were designed for use by the main small game species in the Iberian peninsula: red–legged partridge, rabbit and Iberian hare (Lepus granatensis). As red–legged partridges and rabbits were present in all the plots during the study period (Iberian hares were found at much lower densities), and as previous research has shown small game species use the same water troughs (Lacasa et al., 2010), we expected partridges and rabbits to be photographed together at the plots and possibly drinking at the same time.

**Data collection**

We used digital motion–sensing cameras (Bushnell Trailscout Pro®, Bushnell Trophy®) to photograph wildlife visiting water troughs. We started with six cameras in 2008, but had eight in place in 2009 and

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**Fig. 1.** A. Example of a ‘protected’ water trough: 1. Metal fence; 2. Trough; 3. Plastic pipe; 4. Water tank; and 5. Camera trap. B. Images of three rabbits drinking at the same time; C. Two drinking rabbits (possibly one juvenile); and D. A rabbit and a red–legged partridge.

**Fig. 1.** A. Ejemplo de un bebedero con cobertura vegetal: 1. Valla metálica; 2. Bebedero propiamente dicho; 3. Tubería plástica; 4. Depósito de agua; 5. Cámara de fototrampeo. B. Imágenes de tres conejos bebiendo al mismo tiempo; C. Dos conejos bebiendo (posiblemente uno de ellos juvenil); D. Un conejo y una perdiz roja.
photographed drinking, we fitted a GLMM (Agresti, 2007) of the number of rabbits photographed drinking per month, with Poisson error, logarithmic link, ln(possible number of photographs taken for each period of the day), month, period of time (morning, afternoon, evening and night) as fixed factors and year as random factor. Differences with \( p < 0.05 \) were considered significant and all tests were carried out using SPSS© (v. 17.0 for WINDOWS©, IBM Corporation©).

**Results**

After subtracting incidents of cameras and trough malfunctioning (\( n = 152 \)), we monitored troughs during 228 camera–trapping weeks, with a total of 1,546 camera–trapping days. The most common problems were camera malfunctions, photographs not valid for analysis (over–exposure), failures in the water supply, damage to a water system by wild boar (Sus scrofa) or stray dogs (Canis lupus familiaris), and combinations of these problems. Rabbits were photographed during 134 camera–trapping weeks (59%, \( n = 228 \)), taking 3,359 photographs depicting 5,738 rabbits (table 1). From these, 599 rabbits were photographed drinking in 57 camera–trapping weeks (43%). These rabbits were mainly single individuals (95% of photographs), although we also observed rabbits in pairs (4.9% of photographs) and one group of three rabbits (0.1% of photographs) (fig. 1).

The number of rabbits photographed drinking was significantly higher at protected troughs than in open fields in all years (\( p < 0.001 \); table 1). In 2008 and 2010, no rabbits were photographed drinking at open troughs. In protected troughs, 10.5% of the rabbits were seen drinking, while in open troughs, 0.03% of rabbits were seen drinking (table 1). Owing to the few rabbits photographed at troughs in open fields (\( n = 4 \)), we pooled all these troughs for the remaining analysis.

The number of rabbits photographed drinking per trough per week was not significantly correlated to any of the weather variables recorded: air temperature (\( r = 0.08, p = 0.38 \)), relative humidity (\( r = -0.13, p = 0.15 \)), wind speed (\( r = -0.03, p = 0.67 \)), or rainfall (\( r = 0.02, p = 0.75 \)). No month*period interaction effects were found for the number of rabbits photographed drinking per week (table 2). When pooling all years, drinking rabbits were photographed from July to September (98% of the rabbits), though a higher number were photographed in August (54%). Morning was the period of the day with the highest number of rabbits photographed drinking (52%), followed in order by evening (20%), night (19%) and afternoon (9%) (fig. 2).

We observed rabbits and red–legged partridges together in 202 photographs (2008, \( n = 35 \); 2009, \( n = 55 \); 2010, \( n = 112 \), drinking at the same time on three occasions (fig. 1). Most of these photographs (88%) were taken in the morning and early afternoon (7 am–12 am). The remaining photos (12%) were taken in the afternoon–evening (2 pm–8 pm). No photographs of Iberian hares were taken.
Table 1. Number of camera-trapping weeks (N), photos, rabbits, drinking rabbits per year and location, and comparison of the number of drinking rabbits photographed between open and protected water troughs using the $\chi^2$–test. (The number of camera-trapping weeks in which rabbits were photographed is given in brackets.)

| Year | N     | Photos | Number of rabbits photographed | Number of drinking rabbits photographed |
|------|-------|--------|-------------------------------|----------------------------------------|
|      |       |        | Open | Protected                  | Open | Protected         |
| 2008 | 42 (24)| 269    | 0   | 1,042                      | 0    | 138               |
|      |       |        |      | $\chi^2 = 15.55, p < 0.001$ |      |                   |
| 2009 | 110 (58)| 716   | 34  | 1,446                      | 4    | 135               |
|      |       |        |      | $\chi^2 = 21.31, p < 0.001$ |      |                   |
| 2010 | 76 (52)| 2,374  | 86  | 3,130                      | 0    | 322               |
|      |       |        |      | $\chi^2 = 11.19, p < 0.001$ |      |                   |
|      | 228 (134)| 3,359 | 120 | 5,618                      | 4    | 595               |

Discussion

We confirmed that rabbits tended to use protected troughs over those in open spaces. Use of troughs was highest from July to September, and most photographs were taken during the morning. Although rabbits survive conditions of water restriction (Hayward, 1961; Cooke, 1982), we observed drinking behaviour in 43% of the troughs where rabbits were detected. Our results confirm moderate use of troughs by rabbits, a finding in agreement with a previous study in the same area using different methodology (Lacasa et al., 2010). However, we did not study rabbit activity at plots without troughs so we are unable to determine whether water was the main reason for visiting the plots. At troughs
where no drinking behaviour was recorded, rabbits may have been attracted by other reasons, such as cooler temperatures around shrub cover. Our results should be considered with caution as the location of troughs did not change during the summer. Further studies are needed to address individual drinking patterns and to evaluate drinking behaviour at Iberian locations with a different climate.

As expected, most drinking rabbits were detected at protected troughs (only two open troughs were used), also in agreement with the previous study conducted in the same area (Lacasa et al., 2010). These findings suggest that protected troughs offer safer conditions for watering, in accordance with the anti–predator strategy of this species (Moreno et al., 1996). The number of rabbits drinking at open troughs was very low, suggesting rabbits prefer closed troughs more than other trough visitors such as red–legged partridges and chukar (Alectoris chukar) partridges (Larsen et al., 2007; Larsen et al., 2009; Sánchez–García et al., 2012b). These findings suggest the location of troughs should therefore be considered in management strategies targeting rabbits. Our results are in line with other studies showing the high need for cover and refuge for this species (Moreno et al., 1996; Lombardi et al., 2007).

The number of rabbits photographed drinking per trough per week was not clearly associated with the weather variables studied, though the number of drinking rabbits was highest in August. It may be that rabbits did not need water when food moisture content met their needs, a notion demonstrated in small species of birds (Degen et al., 1984). We did not study food moisture, however, and this is one of the main limitations of this study. It is likely that the strips of game crops distributed throughout the property and delayed crop harvesting (end of June) resulted in quality herbaceous communities with adequate water content. This might explain the higher number of drinking rabbits photographed from July to September, especially in August, when food moisture may have been depleted. We cannot rule out the possible effects of different rabbit density and activity across months on the number of rabbits observed drinking, but it is known that rabbits reduce breeding activity in summer (Gonçalves et al., 2002) and the activity rate observed in captive–reared rabbits at the same site was very low during the second half of the year (Díez et al., 2013). Our study was carried out from late spring to early autumn only. It could be of interest for future research to investigate water needs throughout the whole year.

Rabbits drank mainly during the morning in all months, followed by evening and night drinking behaviour recorded during the afternoon was very low. The drinking pattern was similar to the general activity pattern observed in wild populations (Villafuerte et al., 1993) and in the pattern for reared rabbits in the same area (Díez, 2005), both of which showed lower drinking activity in the afternoon and evening. Rabbits and other lagomorph species are known to be inactive during harsh climatic conditions (Mykytowycz & Rowley, 1958; Wallage–Drees, 1989), so it is possible that rabbits were reluctant to use the troughs during the hottest and driest periods of the day, which in our study site were late morning to early evening. Rabbits may have conducted other activities in the evening and at night, such as foraging (Mykytowycz & Rowley, 1958; Villafuerte et al., 1993), watering then during the morning before resting. Neither can we rule out effects of the predator community on rabbit watering behaviour (at the study site mainly foxes and raptors, see Lacasa et al., 2010). In the grey partridge (Perdix perdix), the use of feeders is higher at dusk and dawn when diurnal and nocturnal predators are respectively less active or not yet active (Potts, 2012).

As expected, we photographed rabbits and red–legged partridges around troughs at the same time, mainly during the morning and early afternoon, the time of the day when partridges concentrate their visits to the troughs (Sánchez–García et al., 2012b). The small number of photographs showing the two species drinking simultaneously could be attributed to the size of the trough, which allowed a limited number of animals at the same time. We did not observe any antagonistic behaviour between species and in situ observations suggest that rabbits and partridges shared the same trough. Further studies at other sites using models with a larger water area (such as small ponds) are needed to confirm the simultaneous use of watering sites rabbits and partridges.

Owing to rabbits’ frequent use of water troughs in our study and the possible effectiveness of this strategy when compared to other techniques (Ferreira et al., 2014), game managers and practitioners aiming to favour rabbit populations through water supply should allocate troughs close to shrub cover and ensure that water is supplied during the summer. For management or research purposes, human visits to water troughs should be conducted between 11 and 16 h in areas with a similar climate as this is the period of the day when rabbits are less active and drink less.

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Table 2. Results of the GLMM models explaining variation in number of drinking rabbits photographed in relation to month, to period of the day, and to interaction between month and period of the day: W: Wald statistic; F: F statistic.

| Fixed term   | W     | F      | p    |
|--------------|-------|--------|------|
| Month        | 46.91 | 11.73  | < 0.001 |
| Period       | 30.97 | 10.32  | < 0.001 |
| Month*period | 12.76 | 1.06   | 0.416 |

Where: W: Wald statistic; F: F statistic; Fixed term: Month, Period, Month*period.
The use of water troughs for wildlife has been widely questioned as it can be viewed as a disturbance of natural ecological processes, but available research does not always support negative effects (Simpson et al., 2011). Although water troughs may help to increase rabbit density, further research is needed to understand the effects of water supply on rabbit ecology and to determine the factors triggering the use of troughs by rabbits (such as lack of food moisture). Such knowledge could help adapt management decisions to different scenarios.

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