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What is better for animal conservation translocation programs: soft- or hard-release? A phylogenetic meta-analytical approach

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Abstract

1. Animal conservation translocation is an important tool available to conservation biologists to address problems of isolated, declining or endangered populations. This approach includes both captive-bred and free-ranging origin animals, which are used to rescue genetically limited populations and re-establish extirpated populations. Both soft and hard release protocols (the release of animals with or without acclimatization, respectively) are used in animal conservation translocation programs; however, there is no consensus on whether one has better conservation outcomes than the other.
2. Here, we analyzed data from 17 studies to measure the efficiency of both techniques for fauna conservation. Using phylogenetic meta-analysis, we compared results from articles that used soft and hard release protocols to determine the overall effect size. In addition, we examined if the success metrics, type of environment, taxonomic group, and animal's origin affected the outcomes of each type of translocation programs.
3. We calculated 61 effect sizes for 17 species. We found that the soft-release protocol is approximate 40% better than the hard-release protocol (Estimates = 0.44, CI95: 0.11 – 0.76). Soft-release program increased success by 77% (Estimates = 0.78, CI95: 0.37 - 1.19) when movement metrics were used (as compared to hard-release) and were 41% more successful with terrestrial species.
4. In general, soft releases showed better outcomes by reducing movements away from the release site, but this was driven mostly by terrestrial reptile translocations (77% chance of success); when birds and mammals or the other success metrics were evaluated, both release techniques had similar effects. Lastly, the origin (i.e. captive or wild) of the released animals did not influence the success rate of soft- vs. hard-releases.
5. *Synthesis and Applications.* We conducted a meta-analysis to evaluate which is the best release protocol for success in animal conservation: soft- or hard-release. Our results showed that soft-releases are in general better than hard-releases, especially for reptiles. Protocol outcomes were similar for birds and mammals and were not linked to the origin of the released animals. We recommend that the decision of which protocol to use needs also to consider the financial costs of the used protocol.

Keywords

Animal translocation, Conservation program, Fauna, Hard-release, Meta-analysis, Release technique, Soft-release, Systematic review.

Resumo

1. As translocações de animais são ações importantes para conservacionistas mitigarem problemas de populações isoladas, em declínio ou ameaçadas. Essas ações envolvem a liberação tanto de animais nascidos em cativeiro quanto de animais oriundos da natureza, que são usados para resgatar populações geneticamente limitadas e reestabelecer populações extintas. Ambos os protocolos de liberação suave e dura (a liberação de animais com e sem aclimatação, respectivamente) são usados nos programas de translocação. Entretanto, não há um consenso sobre qual dos dois é melhor para projetos de conservação.
2. Nós analisamos dados de 17 estudos para medir a eficiência dos dois protocolos de soltura na conservação da fauna. Usando uma meta-análise filogenética, nós comparamos os resultados desses estudos para determinar o tamanho do efeito geral. Nós também avaliamos se as métricas de sucesso, tipo de ambiente, grupo taxonômico e origem do animal afetaram o sucesso dos programas de translocação.
3. Nós calculamos 61 tamanhos de efeito para 17 espécies. Nós observamos que o protocolo de soltura suave é aproximadamente 40% melhor que o protocolo de soltura dura (Estimates = 0.44, CI95: 0.11 – 0.76). O protocolo de soltura suave aumentou o sucesso em 77% (Estimates = 0.78, CI95: 0.37 - 1.19) quando a métrica de movimento foi usada e em 41% quando a espécie solta era terrestre.
4. No geral, a soltura suave gerou resultados melhores por reduzir a movimentação dos indivíduos, mas isso ocorreu principalmente para translocações com répteis terrestres (77% de chance de sucesso); quando aves e mamíferos ou qualquer outra métrica de sucesso era avaliada, ambos os protocolos geravam resultados similares. Finalmente, a origem dos animais não influenciou no sucesso dos protocolos suave e duro.
5. *Síntese e Aplicações.* Nós conduzimos uma meta-análise para avaliar qual é o melhor protocolo de soltura para a conservação animal: soltura suave ou dura. Nossos resultados mostraram que a soltura suave produz resultados melhores do que a soltura dura, especialmente para os répteis. Os resultados foram similares para aves e mamíferos e não estavam ligados à origem dos animais. Nós recomendamos que a decisão de qual protocolo usar também leve em consideração os seus custos.

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Introduction

Animal conservation translocation programs have become an important tool used by conservationists to recover lost biodiversity (IUCN/SSC, 2013; Seddon, Armstrong, & Maloney, 2007; Wolf, Griffith, Reed, & Temple, 1996). Understanding release protocols and how they work is fundamental to improve the success of a conservation program (Moseby, Hill, & Lavery, 2014). The two release protocols used during animal conservation translocation are: soft- and hard-release (Sasmal et al., 2015). Soft-release normally includes: an acclimatization period; pre-release animal training; and post-release food supplementation (Mitchell, Wellicome, Brodie, & Cheng, 2011). Hard-release is the direct release of individuals without any previous acclimatization, training or supplementation (Hardman & Moro, 2006). Both protocols include planning, which determines the choice of release site and the source of the animals (IUCN/SSC, 2013). Many questions about the efficacy of these two animal release protocols remain due to the many failures where none of the released animals survived (Beauchamp, 2000; Ewen & Armstrong, 2007; Taggart et al., 2015; Yott et al., 2011).

Uncertainty over the outcome of these two protocols has caused problems for conservationists who wish to ensure the successful establishment and persistence of the species' population in their new locality. This uncertainty generates questions such as: (1) Are the financial resources being used effectively? (most conservation efforts have limited budgets); (2) How many individuals should be released? (there is a finite number of animals that can be released, especially when the species is threatened with extinction); (3) How much time should be dedicated to monitoring/supporting released animals? (with logistics, environmental education activities, etc.). The answers to these questions are difficult to find because animal conservation releases can be based on the dubious results of previous studies (Berger-Tal, Blumstein, & Swaisgood, 2020). Thus, it is important to determine methods to diminish this uncertainty (i.e. improve decision-making). For example, the African wild dog (*Lycaon pictus*) (Gusset, 2009) and the Arctic fox (*Vulpes lagopus*) (Landa et al., 2017) have both had successful outcomes in response to soft-release protocols. On the other hand, the soft-release of hare-wallabies (*Lagorchestes hirsutus* and *Lagostrophus fasciatus*) (Hardman & Moro, 2006) and the stitchbird (*Notiomystis cincta*) were unsuccessful (Richardson, Castro, Brunton, & Armstrong, 2015a). The same variability in outcomes was also observed in hard-release programs [successful: Rummel et al., 2016 (this is a revision paper where various species were evaluated); unsuccessful: Tennant & Germano, 2017

(Heermann's kangaroo rat, *Dipodomys heermanni*)]. The unsuccessful results of the cited conservation efforts, both for soft and hard-release efforts, were associated with dispersion by the individuals and a decrease in body condition of the released individuals. In soft releases, these adverse effects of soft-release were caused by the stress of being in captivity, which resulted in decreased adaptability to a new environment, and due to intraspecific aggression resulting from competition for burrows (Hardman & Moro, 2006; Richardson, Castro, Brunton, & Armstrong, 2015b; Tennant & Germano, 2017) respectively). Success in conservation translocation programs is normally inferred from: survival rate, reproduction of the released animals and their offspring, and in the long-term the establishment of viable populations of the released animals (IUCN/SSC, 2013). However, the release site (environment) and the biological characteristics of the released species (biology), including its origin (i.e. wild-caught or captive-born) are of crucial importance for success of conservation translocation programs (Grey-Ross, Downs, & Kirkman, 2009). Therefore, determining how successful animal conservation translocation programs are is difficult, especially as there is no universally accepted definition of success (Gusset, 2009).

Terrestrial mammals and birds are more frequently released than fish, amphibians or reptiles (Bajomi, Pullin, Stewart, & Takács-Sánta, 2010; Seddon, Soorae, & Launay, 2005; Soorae, 2018). The number of terrestrial animal conservation translocation are greater than the number of aquatic animal conservation translocation (Olden, Kennard, Lawler, & Poff, 2011), and the use of soft-release protocols is more frequent than the use of hard-release protocols (Resende, Viana–Junior, Young, & Azevedo, 2020). Most of the conservation translocation individuals come from captive populations, where the application of soft-release techniques is favored (Jule, Leaver, & Lea, 2008; Tenhumberg, Tyre, Shea, & Possingham, 2004). Since captive-born animals typically do not experience predator encounters, do not need to forage to obtain food or to search for shelter and mates, the release of these naïve animals without any prior preparation is normally avoided. The preparation of captive born individuals consists in a series of survival skill training sessions prior to released (e.g. anti-predator, food, flight, etc.) (Griffin, Blumstein, & Evans, 2000; Lopes et al., 2017; Tetzlaff, Sperry, & DeGregorio, 2019). Wild caught individuals, on the other hand, are normally hard-released to avoid a prolonged contact with humans to minimize: habituation to humans, stress, injuries and disease transmissions (Rummel et al., 2016; Teixeira, de Azevedo, Mendl, Cipreste, & Young, 2007).

There are several methods to evaluate the success of animal conservation translocation programs. The distance travelled by the animals after being released is used as a measure of success or failure, depending on the biological characteristics of the species (if the species is able to travel long distances because of its physiology, behavior, anatomy, size, etc.). It is expected that individuals will travel for longer distances soon after release, because they are exploring and learning about the characteristics of their new environment. If the individuals decrease their movements in the area, they may establish themselves in the area, and this has been interpreted as a successful outcome (Berger-Tal & Avgar, 2012; Berger-Tal & Saltz, 2014; Russell, McMorland, & MacKay, 2010). However, if the animals increase their movements, eventually leaving and not returning to the release area, this could be interpreted as a failure, because the individuals did not establish themselves in the release area (Berger-Tal & Saltz, 2014; Stamps & Swaisgood, 2007). The number of times an individual is recaptured is also used as a measure of success in conservation programs (de Milliano, Di Stefano, Courtney, Temple-Smith, & Coulson, 2016; Sacerdote-Velat, Earnhardt, Mulkerin, Boehm, & Glowacki, 2014). If the released individuals are being constantly recaptured, this may indicate that they are not able to live in their new area (e.g. not finding enough food, shelter or conspecifics). Moreover, an increase in recaptures can mean that the animals have become habituated to humans and dependent on their care (Lopes et al., 2018; Waples & Stagoll, 1997).

Another important metric is body condition: if body condition remains good after release this could be a measure of success (Morfeld, Meehan, Hogan, & Brown, 2016; Stevenson & Woods, 2006; Zielke, Wrage-Mönnig, & Müller, 2018). The weight of the animals, for example, can also be used as a metric evaluating success in release programs, if the individuals are gaining weight after release, especially in the long-term, then the conservation translocation program is considered successful (Cid, Figueira, Mello, Pires, & Fernandez, 2014). However, aspects related to the size/weight of the species has never been evaluated as a factor affecting success of conservation translocation programs. Larger animals may be more difficult to manage in captivity for soft-release because of the size of enclosure necessary to train skills such as predator avoidance, for example (Griffin, Blumstein, & Evans, 2000) Furthermore, it may be easier for predators to locate them, it may be more difficult for them to find shelter, and they may need to consume more food in the release habitat (Cohen, Pimm, Yodzis, & Saldana, 1993; Gaston & Blackburn, 1995; Stuparyk, Horn, Karabatsos, & Arteaga, 2018). Therefore, to evaluate if the animals' size/weight influence conservation translocations' success would be important, and could influence pre-release behavioral management, since it can enhance survival skills.

Although quantitative reviews regarding animal release programs have been published (Tetzlaff et al., 2019), an approach comparing the success of these protocols (soft- and hard-release) is still lacking. The use of meta-analytic techniques can help, in the understanding and quantification of which release protocol is best for a successful animal conservation translocation program. This article provides the first meta-analysis of studies comparing the success of the two release protocols, soft- and hard-release, as well as quantifying the effects of different metrics, type of environments, taxonomic group, individual's origin and species' normal body weight.

We predict, in general, that soft-release will be more successful than hard-release due to the behavioral management received by the animals prior to release. Since different studies quantify programs' success based on different metrics, we expect that the program's success will depend on the metric used in the study. Another prediction is that soft-release will be more successful than hard-release for terrestrial, captive-born and small animals, because acclimatization prior to release would be important to reduce stress-related problems, to increase body condition and to improve survival skills (i.e. anti-predator, social, food and locomotion training/learning). Lastly, we predict that hard-released animals will have better outcomes than soft-release for aquatic, wild-caught and large animals, because of the shorter time period of human-contact (i.e. less stress-related and behavioral problems due to captivity and human contact) and greater amount of energy stored in its body due to the size of the animal. Our results will be important for future conservation translocation programs by clarifying the best release protocol to be used.

Materials and Methods

Data collection

We used the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol for paper search (Moher et al., 2000). We searched for peer-reviewed scientific papers published from 1986 to 2018 using the Scielo©, Web of Science© and Scopus© databases. We used the following keywords in our searches: "*hard-release*", "*soft-release*", "*wildlife reintroduction*", "*wildlife translocation*", "*wildlife introduction*", "*release of wild animals*", "*animal reintroduction*", "*animal introduction*", "*animal translocation*", and "*animal rewilding*". Keywords were used individually and in all possible combinations. The inclusion criteria allowed only peer-reviewed studies that reported means, sample sizes and the variance of both hard and soft releases (tested variables are listed in the next section). We only included papers that compared both release protocols, papers focusing on the introduction of exotic species were discarded. The moderator variables considered to calculate the effect size were standardized mean differences between movement, body condition, physiology, recapture, and survival reported in the studies.

Meta-analysis

Individual effect sizes were calculated using standardized mean differences {SMD - Hedge's d, (Rosenberg, Adams, & Gurevitch, 2000)}. Positive effect values, when SMD > 0, indicated that soft-release was more successful than hard-release, and negative effect values, when SMD < 0, indicated that the hard-release protocol had a higher effect compared to the soft-release protocol. Eight studies described negative effect sizes (e.g., movement distances of the animals after release), which were associated with a positive reintroduction effect. We converted those effect sizes to positive values to be consistent with the use of SMD as described above (e.g., a decrease in movement in some soft-release studies that were ultimately successful; that is, 24 comparisons in total).

After calculating effect size for each comparison, we used a phylogenetic multilevel meta-analytic models, using the R package metaphor (Viechtbauer, 2010). These models should be used when there is non-independence of individual effect sizes. The phylogenetic multilevel meta-analytic models is known as a flexible meta-analysis method due to its ability to accommodate non-independence in the data, induced by multiple studies from the same research group, scientific paper, same population or species (Mengersen & Schmid, 2013). As random factors, we insert in models a phylogenetic covariance matrix and the structure with the variation between-study effect and the within-study effect. To build the phylogenetic covariance matrix we used the taxonomic distances between species as an operational approximation of their phylogenetic distances (Bellay et al., 2015). Taxonomic distance matrix (TDM) was calculated and analyzed according to the following formulae:

$$TDM = dM - (wSpC + wSbC + InC + wSpO + wO + wF + wG + wS);$$

where dM is the maximal distance between two species. Thus, the maximal distance is eight because all species will belong to only one clade of origin of the eight different levels of the classification system, ranging over species (1), genus (2), family (3), order (4), superorder (5), infraclass (5), subclass (7), superclass (8). In the matrix, all pairs of species received zero value (no similarity) and all pairs of species received one value (all equals) in superclass. wSpC, wSbC, InC, wSpO, wO, wF, wG and wS are the matrices constructed by the ‘weight.taxo’ function of the ape package (Paradis & Schliep, 2019) in the program R 3.11 (R Core Team, 2019) for each taxonomic category (superclass, subclass, infraclass, superorder, order, family, genus and species, respectively) (see Table S1 and Figure S1 in Supporting Information).

The phylogenetic approach in meta-analysis is important in ecological studies due to the violation of two assumptions: (1) independence resulting from evolutionary history; and (2) heterogeneity of variance because the data are sampled from a normal distribution with an expected variation (Adams, 2008; Lajeunesse, Rosenberg, & Jennions, 2013). The addition of phylogenetic information improves statistical inference, reducing type I statistical errors due to non-independence of data (Chamberlain et al., 2012; Lajeunesse, 2009). However, several meta-analytical studies demonstrated that the use of the phylogenetic signal to calculate how effect size varies between studies is either being important (Kamiya, O'Dwyer, Nakagawa, & Poulin, 2014; Usui, Butchart, & Phillimore, 2017; Vilà et al., 2015; Xie, Song, Zhang, Pan, & Dong, 2014) or not (Kunc & Schmidt, 2019; Peters et al., 2019; Rifkin et al., 2012; Thayer et al., 2018). Within this perspective, we can highlight whether the phylogenetic signal is important for the outcome of using different animal release protocols.

Mixed-effect models were used with five moderators. The first included the success metrics [i.e., movement pattern (N = 31), body weight (N = 10), recaptures (N = 3), physiology (N = 8), and survival (N = 9)]. The second moderator was the type of environment [aquatic (N = 100), terrestrial (N = 51)] used by the animal. The third was taxonomic group [birds (N = 7), mammals (N = 31), reptiles (N = 23)], and fourth was the animal's origin [captive-born (N = 24), wild-caught (N = 29)]. The fifth moderator was mammal weights, these were taken from the Animal Diversity Web website (Myers, Espinosa, Jones, Hammond, & Dewey, 2019). A linear regression analysis using the mean value for each species was performed to investigate the relationships between the effect size for each comparison and the mammals' weights.

To examine possible publication bias as well as the strength of our results, we calculated Rosenberg fail-safe numbers and used the graphical tools, funnel plot and scatterplots of cumulative effect (Fragkos, Tsagris, & Frangos, 2014; Rosenberg, 2005; Rosenthal, 1979). The Rosenberg fail-safe numbers is the number of studies required to refute significant meta-analytic means: small numbers represent problems in the analysis, whereas larger numbers represent good results (Rosenberg, 2005). We used heterogeneity analyses (Q statistic) to test homogeneity of categorical groups with respect to effect sizes. We calculated the total heterogeneity (Qt) for all effects tested, as well as heterogeneity within (Qw) and between groups (Qb), all of which follow a χ^2 distribution, which was used to determine statistical probabilities (Bowden, Tierney, Copas, & Burdett, 2011).

Results

We found 1119 scientific papers (500 in Scielo©, 201 in Web of Science© and 418 in Scopus©). Of these, 209 were eliminated because they were duplicates and 893 because they were not about the subject of interest or they were not about studies that compared hard and soft-release protocols. Thus, the final meta-analysis included 17 articles that directly compared hard and soft-release protocols (see Figure S2 in Supporting Information).

We calculated 61 effect sizes in 17 studies from 17 species, mostly mammals ($n = 10$ species) and reptiles ($n = 4$), with only three from birds. Studies took place in six countries, eight of which were conducted in the USA, three in Australia, three in New Zealand, one in Japan, one in Canada and one in France (see Figure S3 in Supporting Information). Each study reported between one to seven effect sizes that varied from -2.54 to 4.42. Nineteen effects were positive, four effects were negative, and 38 effects included zero inside of 95% confidence interval (CI95). We found that the overall mean of effect size (based on phylogenetic multilevel meta-analytic models) was significantly positive (SMD = 0.44, CI95: 0.11 – 0.76, $P < 0.05$; Figure 1) indicating than soft-release protocols were more successful than hard-release ones across all metrics combined (i.e. type of environment, taxonomic group or animal origin). Total heterogeneity was high and significant ($Q = 223.12$; $P < 0.001$), the heterogeneity due to random effect within- and between-study was moderate (within-study - Estimates = 0.20, Square root = 0.45; between-studies - Estimates = 0.32, Square root = 0.56), while heterogeneity due to phylogeny was nonexistent (Estimates < 0.00001, Square root = 0.00011). This result means that when the phylogeny of the groups was considered (comparison between models with and without phylogeny), the variation between studies was heterogeneous, but not significantly influenced by the phylogenetic signal.

When observing the effect sizes based on different moderators, we found more positive outcomes for soft-release than for hard-release in most of the metrics (Figure 2). Of all metrics used to quantify success between the two animal release protocols, only metrics used to verify animal movement were significant. Soft-release program success increased by 77% (Estimates = 0.78, 95% CI: 0.37 to 1.19) when movement metrics were used as compared to hard-release (Figure 2). Parameters such as body weight, recaptures, physiology, and survival did not significantly differ between the two animal release protocols (Figure 2). When we compared the environment type of the species, we observed that conservation translocation had 41% more chance to be successful when terrestrial species were released using the soft-release protocol, but no effect for aquatic organisms (Terrestrial: Estimates = 0.41, 95% CI: 0.05 to 0.78; Aquatic: Estimates = 0.53, 95% CI: -0.37 to 1.45). Interestingly, both release techniques had similar effects for mammals and birds, however, reptiles had 75% chance of success when the soft-release technique was used (Birds: Estimates = 0.02, 95% CI: -0.77 to 0.82; Mammals: Estimates = 0.37, 95% CI: -0.08 to 0.82; Reptile: Estimates = 0.75, 95% CI: 0.19 to 1.32). Lastly, captive-born and wild-caught animals had similar success using both soft-and hard-release protocols. Animals' weight had no significant effect on mammal release outcomes (Figure 3). The effects of weight for reptiles and birds were not evaluated due to the low number of species available (three species of birds and four species of reptiles), which prevented robust analysis.

For all moderators we found non-significant differences in the heterogeneity, indicating homogeneity among the parameters used (Metrics: $Q_B = 9.01$, df = 4, P = 0.06; Environment: $Q_B = 0.09$, df = 1, P = 0.76; Taxonomic groups: $Q_B = 2.33$, df = 2, P = 0.31; Origin: $Q_B = 0.68$, df = 1, P = 0.40). Fail-safe numbers for overall effects (878 studies), for effects movements (587 studies), terrestrial animals (609 studies) and reptiles (252 studies) were large relative to the number of independent comparisons included in the meta-analysis (61 studies, 31 studies, 51 studies and 23 studies, respectively), indicating the strength of our results. We did not find evidence of publication bias from a visual inspection of funnel plots (effect size vs. sample size), and a lack of relationship between effect size and publication year (see Figure S4 in Supporting Information).

Discussion

Soft-release protocols tended to have a positive outcome and our data suggests that they are 45% more successful than hard-release in conservation translocation. Thus, the time during which the animals acclimate at the release location, which can be accompanied by supplementation of food and water, as well as training against predators, increases the likelihood of success of the conservation translocation program (Kleiman, 1989).

Additionally, animals that are soft-released tended to remain at or near the release site, and this increased the chance of conservation translocation success by 77%. Metrics that are used to quantify success of conservation translocation programs should be clearly stated. For example, many studies used movement patterns after release as the main proxy to indicate successful release. Movement is an important metric, since it can indicate that the animals are exploring their new environment or establishing a new territory (Devineau et al., 2010; Moseby et al., 2014). However, it also can indicate that the release site was not adequate for the animals, and that the animal is searching for a new site. Also, during movements, the risk of being predated, culled by hunters, or vehicle collisions are increased (Berger-Tal & Saltz, 2014; Devineau et al., 2010). In our analysis, animals that were soft-released remained for a longer time in the release site than those hard-released.

The reduction of homing behavior by anchoring the species to the location of the release site is one of the main purposes of the soft-release protocol (de Milliano et al., 2016; L.T.B. Hunter et al., 2007). The time period that animals spend in the soft-release pens helps then to acclimate to their new environment, increasing site fidelity (Luke T B Hunter, 1998), and increases their survival skills (e.g. finding food and shelter, to deal with different sounds and smells, to the establishment of social relations, etc.), especially for captive-born individuals (Goldenberg et al., 2019; Lopes et al., 2017, 2018). The results found in the present study confirms that these pre-release pens positively affect conservation outcomes. The question of whether long-distance dispersal affects translocation success should be key in determining which protocol to use. Nevertheless, we believe that movement is not the most appropriate metric to infer success or establishment of the released animals in the release site, since this is species dependent.

Survival, reproduction, population establishment, and other behaviours may be better metrics, which should be used to infer conservation success. Although the establishment of viable populations of the species is proposed as the best metric for the evaluation of release success (IUCN/SSC, 2013), it was not used in any of the papers we analysed. Some authors argued that the high costs of the monitoring and the long time needed for population establishment were the main causes for not using such measure. We believe, whenever possible, that the long-term monitoring of the released animals should be done. To reduce costs, technology such as camera traps can be used as a cheaper method to monitor animals, especially if they can transmit images back to the conservationists (Nazir et al., 2017).

Our results showed that the soft-release of terrestrial species increases relocation success by 41%. This result could reflect bias in our sample, since more than 88% of the studies considered were conducted with terrestrial species (they are easier to observe, to capture, to mark, etc.) or due to the preference for charismatic species, often terrestrial (Albert, Luque, & Courchamp, 2018). Also, disproportionate attention seems due to the phylogenetic nearness to humans (Martín-López, Montes, Ramírez, & Benayas, 2009; Wilson, Şerban, Braschler, Dixon, & Richardson, 2008). More studies comparing the results of soft and hard-releases for aquatic species are necessary to strengthen our findings.

Reptiles also responded better to soft-release with 75% of re-introductions considered successful (Ewen, Soorae, & Canessa, 2014). This may be simply due to behavioural differences in reptiles, which responded less adversely to captivity (i.e. adapt less) (Santos, Pérez-Tris, Carbonell, Tellería, & Díaz, 2009). In 2014, a study that tested different release protocols for species, recommended protocols to be species-specific, because intrinsic factors of each species are likely to influence release success (Moseby et al., 2014).

The origin of the animals (captive-born or wild-caught) generated similar results on the success of the conservation translocation programs. Hard-release may be more effective for wild-born animals, or for those that were only briefly in captivity, because both may simply behave more naturally once released (Maehr, Noss, & Larkin, 2001). Animals born in captivity (or held in captivity for a prolonged time period) should be soft-released to allow for learning (i.e. anti-predator responses, foraging, shelter finding, etc.) to ease adaptation to their new environment (Lopes et al., 2017, 2018; Sutherland et al., 2010). Thus, we suggest that the technique chosen should be based on the history of the individuals to be released (captive-born or wild individuals) or on the amount of money available for the conservation program.

Ontogenetic differences in the behaviour of individuals should also be considered, since behaviours can differ depending on an individual's age (Dias, Stein, & Fialho, 2017; Patoka, Kalous, & Bartoš, 2019; Wenzel, 1992). Conservation translocation studies should inform the age class of the released animals and this parameter should be included in the meta-analysis to evaluate if success is related to the age of the individuals and, consequently, associated with behavioural development.

For mammals, body weight did not affect the outcomes of the conservation translocation programs for either of the release protocols. Our sampling number was low for reptiles and birds (only three bird species and four reptile species) and, therefore, the relationship between animal weight and release success could not be evaluated. This result agreed with others showing a species bias in conservation studies (Bajomi et al., 2010; Seddon et al., 2005). For a more robust evaluation of the effects of body weight on the success of conservation translocation, we suggest more studies comparing both release protocols for reptiles and birds.

In summary, we predicted that soft-release would tend to be more successful than hard-release for captive and terrestrial animals, because acclimatization prior to release would be important to diminish stress-related problems (Teixeira et al., 2007), to increase body condition and to increase survival skills (anti-predator, social, food and locomotion training/learning). We also predicted that hard-release would tend to be more successful than soft-release for wild-caught and aquatic organisms, because of the shorter human-contact (i.e. less stress-related and behavioural problems), greater amount of body-stored energy due to the size of the animals. Our results corroborated only part of our predictions, with soft-release resulting in better outcomes for terrestrial animals, especially reptiles, while hard-release presented better results for aquatic reptiles.

The decision of what protocol to use needs also to consider the costs of soft and hard-release. Soft-release is usually much more expensive than hard release. Hard release often involves greater numbers of animals. In a cost-benefit analysis, which is better? That is, should conservationists invest in breeding animals and then releasing lots of them using hard release? Or should they spend their money supporting fewer animals to ensure a higher survival rate? A cost-benefit analysis needs to be conducted, and we recommend that future studies should do this and make the relevant data available. Ethically we could argue that soft release is better, if it results in higher survival rates.

We need more studies of other taxonomic groups to better predict the conservation outcomes under each release protocol, including fish. It is important to state that some of our results could be interpreted differently if we accepted a *p*-value threshold different from 0.05 (Hurlbert, Levine, & Utts, 2019) or if we had a larger number of studies. Finally, most studies using both releasing protocols were carried out in a few temperate regions, and so more studies are required in the tropics, where many more species are endangered. Such studies will provide invaluable information to better understand the efficacy of translocation programs for animal conservation. A well-developed release strategy based on previous work will better define release methods for pre-release and release phases of the many taxonomic groups that are currently threatened with extinction.

Authors' contributions

PSR, ABVJ, RJY and CSA conceived the ideas and designed methodology; PSR collected the data; PSR, CSA and ABVJ analysed the data; PSR, ABVJ, RJY and CSA led the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

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Data Availability Statement

Data available from the Dryad Digital Repository https://doi.org/10.5061/dryad.xgxd254d5 (Azevedo et al. 2020).

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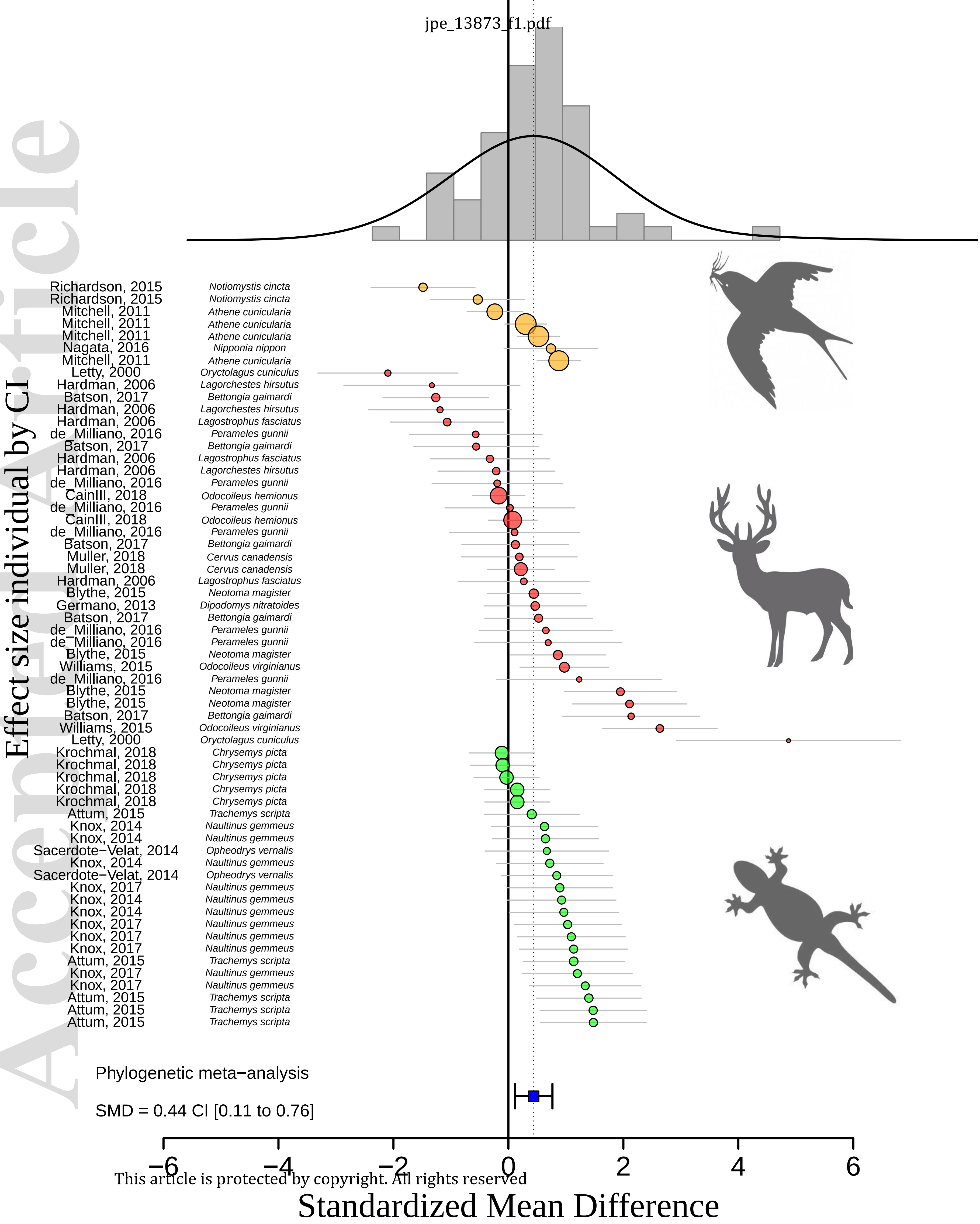
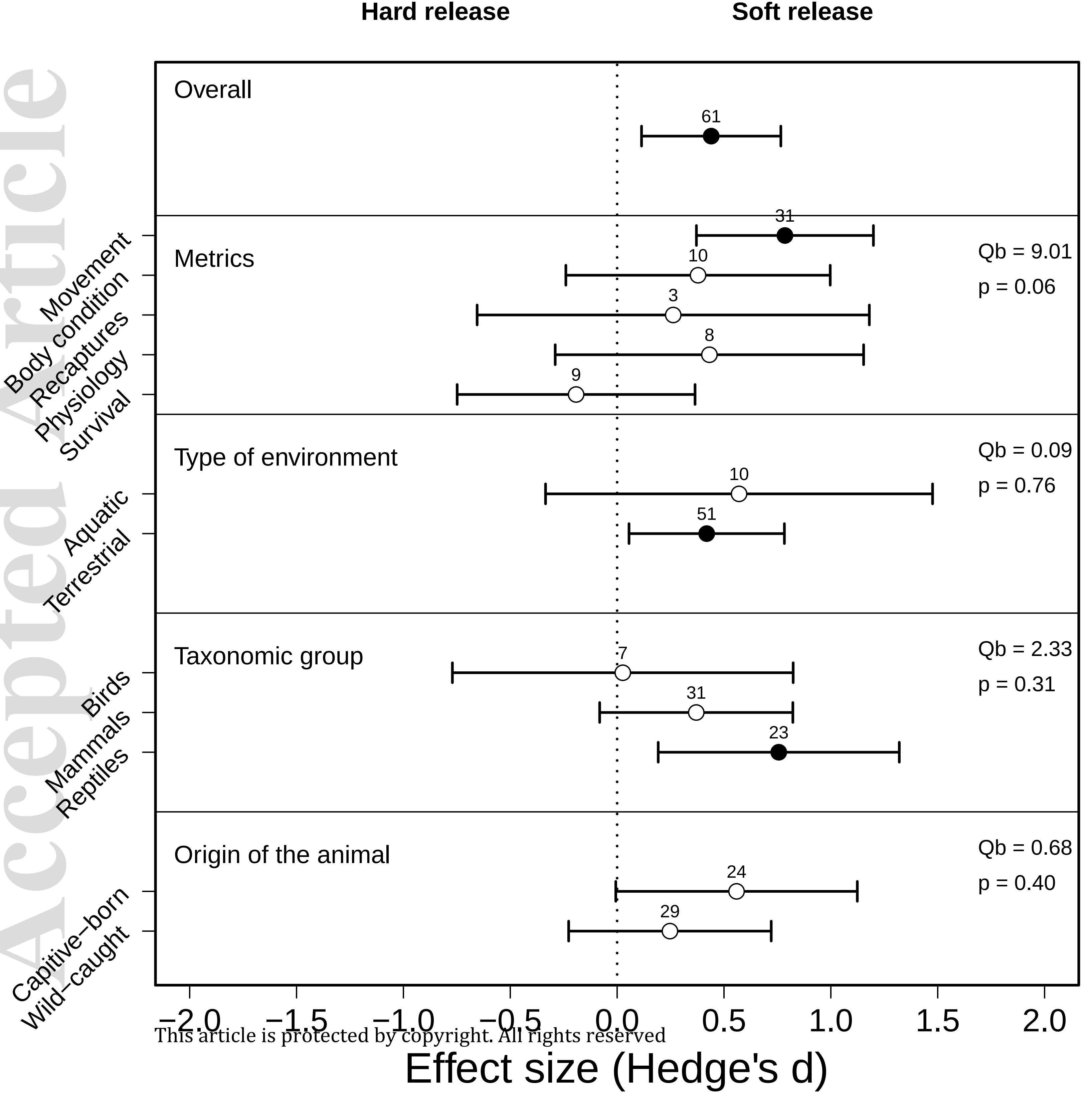
Figure captions

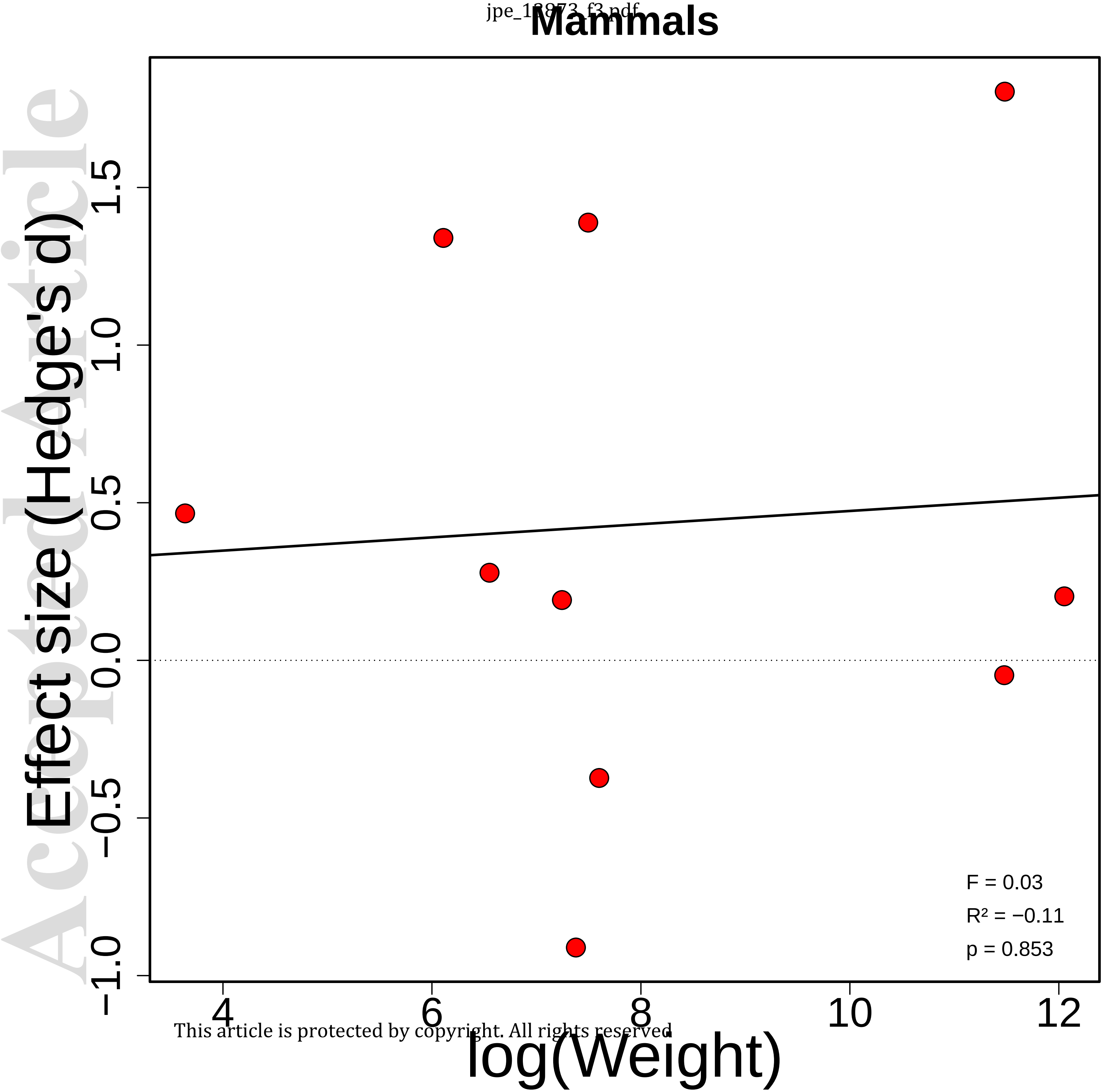
Fig. 1. Forest plot of the 61 effect size estimates in all studies examined, separated by animal class. At the top of the histogram is the distribution of effect size. Beneath the histogram, the standardized mean difference (SMD, effect size) indicated by the circles with colors; each color indicated the taxonomic group of the released animals (orange: bird; red: mammal; green: reptile). Horizontal grey lines indicate 95% confidence interval (CI) of the effect size. Circle size is proportional to the precision (1/Std. Error) of the effect size. The blue square near the bottom is the estimated overall weighted mean effect (SMD) based on a phylogenetic multilevel meta-analytic model.

Fig. 2. Effect size estimates based on mixed effect models. Here we compare the effect size based on the moderators used. If the confidence interval includes zero, we considered the effect to not be significant (white circles) and black circles represents significative effect size (confidence intervals that do not overlap zero). Qb (Qbetween) represents the statistical test of heterogeneity between groups of studies and is used to test whether the pooled effect sizes among the groups differ. Numbers above the mean values indicate the number of comparations.

Fig. 3. Relationship between the effect size (Hedge's d) and the weight (log) of the released species of mammals. No effects were observed for mammals.


Effect size individual by CI
Richardson, 2015 Notiomystis cincta
Richardson, 2015 Notiomystis cincta
Mitchell, 2011 Athene cunicularia
Mitchell, 2011 Athene cunicularia
Mitchell, 2011 Athene cunicularia
Nagata, 2016 Nipponia nippon
Mitchell, 2011 Athene cunicularia
Letty, 2000 Oryctolagus cuniculus
Hardman, 2006 Lagorchestes hirsutus
Batson, 2017 Bettongia gaimardi
Hardman, 2006 Lagorchestes hirsutus
Hardman, 2006 Lagostrophus fasciatus
de_Milliano, 2016 Perameles gunnii
Batson, 2017 Bettongia gaimardi
Hardman, 2006 Lagostrophus fasciatus
Hardman, 2006 Lagorchestes hirsutus
de_Milliano, 2016 Perameles gunnii
CainIII, 2018 Odocoileus hemionus
de_Milliano, 2016 Perameles gunnii
CainIII, 2018 Odocoileus hemionus
de_Milliano, 2016 Perameles gunnii
Batson, 2017 Bettongia gaimardi
Muller, 2018 Cervus canadensis
Muller, 2018 Cervus canadensis
Hardman, 2006 Lagostrophus fasciatus
Blythe, 2015 Neotoma magister
Germano, 2013 Dipodomys nitratoides
Batson, 2017 Bettongia gaimardi
de_Milliano, 2016 Perameles gunnii
de_Milliano, 2016 Perameles gunnii
Blythe, 2015 Neotoma magister
Williams, 2015 Odocoileus virginianus
de_Milliano, 2016 Perameles gunnii
Blythe, 2015 Neotoma magister
Blythe, 2015 Neotoma magister
Batson, 2017 Bettongia gaimardi
Williams, 2015 Odocoileus virginianus
Letty, 2000 Oryctolagus cuniculus
Krochmal, 2018 Chrysemys picta
Krochmal, 2018 Chrysemys picta
Krochmal, 2018 Chrysemys picta
Krochmal, 2018 Chrysemys picta
Krochmal, 2018 Chrysemys picta
Attum, 2015 Trachemys scripta
Knox, 2014 Naultinus gemmeus
Knox, 2014 Naultinus gemmeus
Sacerdote−Velat, 2014 Opheodrys vernalis
Knox, 2014 Naultinus gemmeus
Sacerdote−Velat, 2014 Opheodrys vernalis
Knox, 2017 Naultinus gemmeus
Knox, 2014 Naultinus gemmeus
Knox, 2014 Naultinus gemmeus
Knox, 2017 Naultinus gemmeus
Knox, 2017 Naultinus gemmeus
Knox, 2017 Naultinus gemmeus
Attum, 2015 Trachemys scripta
Knox, 2017 Naultinus gemmeus
Knox, 2017 Naultinus gemmeus
Attum, 2015 Trachemys scripta
Attum, 2015 Trachemys scripta
Attum, 2015 Trachemys scripta
Phylogenetic meta−analysis
SMD = 0.44 CI [0.11 to 0.76]
−6
−4
−2
0
2
4
6
Standardized Mean Difference


Hard release
Soft release
Overall
61
Metrics
Movement
Body condition
Recaptures
Physiology
Survival
31
10
3
8
9
Qb = 9.01
p = 0.06
Type of environment
Aquatic
Terrestrial
10
51
Qb = 0.09
p = 0.76
Taxonomic group
Birds
Mammals
Reptiles
7
31
23
Qb = 2.33
p = 0.31
Origin of the animal
Capitive–born
Wild–caught
24
29
Qb = 0.68
p = 0.40
−2.0
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0
Effect size (Hedge's d)


Mammals
Effect size (Hedge's d)
1.5
1.0
0.5
0.0
−0.5
−1.0
4
6
8
10
12
log(Weight)
F = 0.03
R² = −0.11
p = 0.853