



**QUEEN'S
UNIVERSITY
BELFAST**

Supplementary feeding increases Common Buzzard *Buteo buteo* productivity but only in poor-quality habitat

Rooney, E., Reid, N., & Montgomery, W. I. (2015). Supplementary feeding increases Common Buzzard *Buteo buteo* productivity but only in poor-quality habitat. *Ibis*, 157(1), 181-185. <https://doi.org/10.1111/ibi.12218>

Published in:
Ibis

Document Version:
Peer reviewed version

Queen's University Belfast - Research Portal:
[Link to publication record in Queen's University Belfast Research Portal](#)

Publisher rights

© 2014 British Ornithologists' Union

This is the peer reviewed version of the following article: Rooney, E, Reid, N & Montgomery, WI 2015, 'Supplementary feeding increases Common Buzzard *Buteo buteo* productivity but only in poor-quality habitat' *Ibis*, vol 157, no. 1, pp. 181-185, which has been published in final form at <http://onlinelibrary.wiley.com/doi/10.1111/ibi.12218/abstract;jsessionid=DD687B4EBC03310CF3DFD8583DFF998B.f04t04>. This article may be used for non-commercial purposes in accordance with Wiley Terms and Conditions for Self-Archiving

General rights

Copyright for the publications made accessible via the Queen's University Belfast Research Portal is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

The Research Portal is Queen's institutional repository that provides access to Queen's research output. Every effort has been made to ensure that content in the Research Portal does not infringe any person's rights, or applicable UK laws. If you discover content in the Research Portal that you believe breaches copyright or violates any law, please contact openaccess@qub.ac.uk.

1 **Running head:** *Supplementary feeding of breeding Buzzards*

2
3 **Supplementary feeding increases Common Buzzard *Buteo buteo***
4 **productivity, but only in poor quality habitat**

5
6 EIMEAR ROONEY,^{1,2*} NEIL REID^{1,2,3} & W. IAN MONTGOMERY^{1,2,3}

7
8 ¹*School of Biological Sciences, Queen's University Belfast, Belfast, BT9 7BL, UK.*

9 ²*Quercus, Queen's University Belfast, Belfast, BT9 7BL, UK.*

10 ³*Institute for Global Food Security (IGFS), Queen's University Belfast, Belfast, BT9 7BL, UK.*

11
12 *Corresponding author.

13 E-mail: erooney10@qub.ac.uk

14
15 Temporal heterogeneity in the effects of food supply during the breeding season on the
16 productivity of the Common Buzzard *Buteo buteo* was investigated in a supplementary feeding
17 experiment. Pairs were fed artificially (1) before egg laying, (2) after chicks hatched and (3)
18 continuously throughout the season and compared to (4) unfed controls. Pairs fed *before* egg
19 laying had marginally larger clutches (+0.6 eggs more) than those not fed, but lay date, egg
20 volume and weight, brood size and hatching success were unaffected. Territorial quality had
21 far greater effects, with pairs nesting in low quality habitats (bog, scrub and semi-natural
22 grassland) laying later, having lower hatching success, smaller broods and fewer fledglings
23 than those in more productive agricultural landscapes. Supplementary feeding *after* egg
24 hatching neutralised the negative effect of poor habitat resulting in fed birds having
25 significantly more fledglings. This study emphasises the importance of food availability when
26 provisioning chicks in sub-optimal habitats and has implications for the success of
27 'diversionary feeding' in reducing game-keeper losses to Buzzards (e.g. released pheasants).

28
29 **Keywords:** bird of prey, breeding season, food, human-wildlife conflict, reproductive success.

30 Food dictates the amount of energy available for self-maintenance, growth and reproduction,
31 and thus directly affects fitness (Lack 1954, Martin 1987). However, other ecological factors,
32 including weather, predation, competition and individual experience modify the immediate
33 importance of food supply as a limiting factor on fitness (Krüger 2004, Robb *et al.* 2008).

34 The relationship between food availability and breeding success is important in wildlife
35 management and has been tested frequently (see Newton 1998, González *et al.* 2006, Margalida
36 2010). As different stages in the breeding period require varying energy inputs, and food
37 availability fluctuates temporally, the influence of food may change throughout the season
38 (Lack 1954, Robb *et al.* 2008). However, the interaction between food supply and stage of
39 breeding is investigated infrequently (Gill & Hatch 2002).

40 The importance of food during the breeding season has been tested in supplementary feeding
41 experiments (e.g. Newton 1998). Often food added during the pre-laying stage increases clutch
42 size and brings forward laying date, most notably when territory quality or natural food
43 availability is poor (Newton & Marquiss 1981, Dijkstra *et al.*, 1982, Nager *et al.*, 1997).
44 Although similar studies have contradictory results, many suggest that an increase in clutch
45 size does not necessarily translate to an increase in number of fledglings (Newton & Marquiss
46 1981, Korpimäki & Wiehn 1998, Millon *et al.* 2008). In addition, food provided during the
47 post-hatching stage can influence the success of inexperienced pairs and those in poor quality
48 habitats (González *et al.* 2006, Byholm & Kekkonen 2008).

49 At the western-most fringe of its range, the Common Buzzard *Buteo buteo* population is
50 recovering and expanding following extirpation during the late-19th to mid-20th centuries (
51 Balmer *et al.* 2013), increasing concern about their impact on prey species, particularly those
52 of commercial interest such as game birds (Lees *et al.* 2012). In addition, prey assemblages in
53 part of the Buzzard's range are changing due to introductions of non-native small mammals
54 (Rooney & Montgomery 2013). To test the effects of prey availability throughout the breeding

55 season on the number of fledglings produced, we conducted a pilot supplementary feeding
56 experiment on free-living Buzzards. Moreover, since natural food availability is likely to vary
57 with habitat, we examined the effect of habitat composition around the nest-site and its
58 interaction with supplementary feeding pre-egg laying and post-hatching. We hypothesised
59 that if food availability is the sole driver of reproductive success, pairs fed continuously
60 throughout the breeding season should have higher reproductive output, especially in poor
61 quality habitats.

62

63 METHODS

64 The experiment was carried out between March and August 2011 in north-east Ireland (54°N,
65 5°E) in an area 1,600km². The study area was composed principally of agricultural land (68%)
66 including improved grassland and arable interspersed with low productivity natural habitats
67 (20%) including bog, scrub and semi-natural grasslands as well as broad-leaved woodlands and
68 conifer plantations (8%) or urban areas (3%). Forty Buzzard nest sites were located through
69 vantage point surveys and were randomly assigned to one of four treatment groups; (1) fed
70 *before* egg laying, (2) fed *after* chicks hatched, (3) fed continuously throughout the breeding
71 season and (4) unfed controls. All pairs had been monitored a minimum of one year prior to
72 the experimental study, and there were no sub-adult individuals identified, based on plumage.
73 However, to minimise the effects of age/experience on the experiment all pairs were randomly
74 assigned to treatments. A minimum of 35 days experimental feeding was conducted before egg
75 laying in treatment groups 1 and 3 and 30 days after hatching in groups 2 and 3.

76 Food was provided on a 'T' post erected <30m from the nest. Posts were observed until the
77 prey was seen to be taken by one or both territorial adults. Twenty-six breeding pairs consumed
78 food readily and were used in the experiment. Every two days, beginning on the 1st March,

79 either one Rabbit *Oryctolagus cuniculus* (c. 1,000g) or two Woodpigeons *Columba palumbus*
80 (c. 450g per item) were provided. Both prey species are consumed regularly by Buzzards in
81 the study area (Rooney & Montgomery 2013). The prey type provided on each occasion was
82 randomised. Although pigeon and rabbit differ in calorific content, both represent significant
83 extra food in territories in experimental treatments.

84 Nests were visited shortly after the incubation period started, during which clutch size, mean
85 egg weight (g) and volume (mm³) were calculated following Hoyt (1979). Nests were revisited
86 approximately 30 days later to determine hatching success (the proportion of eggs hatched) and
87 early brood size (the total number of chicks hatched). Brood size measured at <5 days was
88 assumed to reflect the number of chicks hatched, rather than the number of chicks remaining
89 after brood reduction events (i.e. starvation or siblicide), given that these events in Buzzards
90 occurs most often in the second to fourth weeks of the nestling period (Tubbs 1974), and that
91 siblicide in raptors in general occurs most often when young are not being brooded (Newton
92 1979). Hatching date, if not observed directly, was estimated from the stage of development
93 of the oldest chick, which was always <5 days old. Initial laying date at each nest was back-
94 calculated as 35 days prior to hatching of the eldest chick in that nest (Tubbs 1974).

95 Whilst the experiment was designed as a four-level factorial treatment, variables measured
96 *before* hatching could not have been affected by supplementary feeding *after* hatching.
97 Therefore, where the effect of treatment on laying date, clutch size, egg volume, egg weight
98 and early brood size was examined, the two treatment groups fed before egg laying were
99 combined (groups 1 + 3 = 'pre-fed'), as were the two treatment groups not fed before egg laying
100 (groups 2 + 4 = 'not pre-fed'). Similarly, where the effect of treatment on the number of
101 fledglings was examined, those groups fed *after* hatching were combined (groups 2 + 3 = 'post-
102 fed') as were the two treatments groups not fed after hatching (groups 1 + 4 = 'not post-fed')
103 to create a second two-level factor. This allowed the independent effects of supplementary

104 feeding before-and-after egg laying to be examined whilst their interaction effect (i.e Pre-
105 fed*Post-fed) was used to assess their joint contribution to the number of fledglings. Chicks
106 were considered as successful fledglings on a final visit to the nest a minimum of 28 days after
107 hatching (Hardey *et al.* 2009). Visits were only carried out in mild, calm weather to minimise
108 disturbance

109 CORINE landcover type (EEA, 2010) was extracted within a 1km buffer around each nest
110 using ArcGIS 10 (ESRI, California, USA). Variation in the coverage of improved grassland,
111 arable, bog, scrub, semi-natural grassland, broad-leaved woodland, coniferous plantation and
112 urban habitat was reduced by Principal Components Analysis (PCA) with varimax rotation
113 onto a single component axis describing ‘natural landscapes’. This was positively associated
114 with bog and scrub (weighting = 0.835) and semi-natural grassland (weighting = 0.822) and
115 represented 22.6% of landscape variation (eigenvalue = 1.259). There was no confounding
116 effect of PCA scores on treatment (Supporting Information Fig. S1).

117 Lay date, mean egg volume and weight and hatching success were examined using a
118 Generalized Linear Model (GLM) assuming a normal error distribution (tested for *a priori*
119 using Kolmogorov-Smirnov tests) and an identity link function, fitting the two-level factor Pre-
120 fed (yes/no), Habitat (PCA scores) and their interaction (Pre-fed*Habitat). Clutch size and
121 early brood size were examined using identical GLMs but assuming a Poisson error distribution
122 (for count data) and a logit link function. Number of fledglings was also examined using a
123 Poisson GLM, but fitting the two-level factors of Pre-fed and Post-fed, their interaction (Pre-
124 fed*Post-fed), Habitat (PCA scores), the interaction of each factor and habitat (Pre-fed*Habitat
125 and Post-fed*Habitat) and a three-level interaction (Pre-fed*Post-fed*Habitat). All statistics
126 were carried out using IBM SPSS Statistics v19.

127

128 RESULTS

129 Lay date was unaffected by supplementary feeding before egg laying but was positively
130 associated with Habitat ($F_{df=1,17} = 5.42, P = 0.032$) i.e. Buzzards nesting in poor quality
131 landscapes with a high coverage of bog, scrub and natural grasslands typically laid later
132 (Supporting Information Table S1 and Fig. S2). There was a trend for Buzzards that were pre-
133 fed (i.e. before egg laying) to have slightly more (+0.6) eggs than those not pre-fed ($F_{df=1,18} =$
134 $3.67, P = 0.072$). After removing the effect of habitat, the marginal estimated mean clutch size
135 was 3.2 ± 0.5 eggs (mean \pm 95% confidence intervals) for pre-fed pairs and 2.6 ± 0.4 eggs for
136 birds not pre-fed. Neither mean egg volume nor weight was affected by either supplementary
137 feeding or habitat (Supporting Information Table S1).

138 Both early brood size and hatching success were significantly negatively associated
139 with Habitat ($F_{df=1,18} = 13.55, P = 0.002$ and $F_{df=1,18} = 17.30, P = 0.001$ respectively) i.e. the
140 greater the proportion of the surrounding landscape that was low quality habitat, the lower the
141 proportion of the clutch to hatch and the fewer chicks hatched overall (Table S1 and Figs. S3
142 & S4). Total reproductive success (i.e. the number of fledglings) was negatively associated
143 with Habitat ($F_{df=1,18} = 4.37, P = 0.051$), i.e. the greater the proportion of the surrounding
144 landscape that was low quality habitat, the fewer fledglings Buzzards produced (Table S1 and
145 Figs. S5). There was also a significant interaction effect between supplementary feeding *after*
146 the eggs hatched and Habitat, i.e. Post-fed*Habitat ($F_{df=1,18} = 4.49, P = 0.048$). Those pairs that
147 had not received supplementary feeding after the eggs hatched (not post-fed), followed the
148 overall pattern of lower reproductive success in low quality habitats. However, supplementary
149 feeding after hatching (post-fed), significantly altered the outcome where being fed after
150 hatching removed the negative impact of low quality habitat (Fig. 1).

151

152 DISCUSSION

153 Supplementary feeding at the pre-laying stage led to a slight increase in clutch size, but did not
154 increase egg quality i.e. there was no increase in egg volume or weight, nor any increase in
155 brood size, hatching success or numbers of fledglings. This concurs with studies on other
156 raptors (Newton & Marquiss 1981, Korpimäki & Wiehn 1998). Although food availability in
157 spring may affect clutch size, habitat quality had a greater effect on lay date and the number of
158 fledglings. These results affirm the suggestion that small-scale habitat effects are important
159 drivers of breeding success in raptors (Byholm & Kekkonen 2008). Laying date was later in
160 the season and brood size, hatching success and numbers of fledglings were lower in poorer
161 quality habitats, i.e. territories containing a greater area of bog, scrub and semi-natural
162 grassland compared to more productive, agricultural landscapes. Buzzards are typically
163 associated with pastoral agriculture where there is a high density of rabbits (Swann & Etheridge
164 1995). Landscapes composed of bog, scrub and semi-improved grasslands typically have lower
165 rabbit densities as they are less productive, have fewer hedgerows suitable for warren
166 construction and, in the case of bogs, have wet soils which are sub-optimal for burrowing.
167 Taller rank grass may also hinder hunting. Buzzards in northeast Ireland prey predominately
168 on young rabbits during the breeding season (Rooney & Montgomery 2013). Thus, delayed
169 hatching in poorer quality habitats may have prevented Buzzards from exploiting seasonal
170 peaks in prey abundance (Perrins 1970).

171 Newton (1998) emphasized two critical periods of food availability for raptors; pre-laying,
172 when females build up reserves for egg production and incubation, and post-hatching, when
173 adults provision nestlings. Absence of any general effect of supplementary feeding could be
174 interpreted as poor statistical power as a result of a relatively small sample size (given for each
175 model in the Supporting Information Table S1) and the disproportionately large effect that
176 stochastic events may have had on the outcome of the experiment. For example, siblicide
177 occurred at three nests, two of which were in treatment group 2 (fed after eggs hatched), and a

178 freshly dead chick (>5 days old) was found at the base of a tree in an exposed site in treatment
179 group 3 (fed continuously). Alternatively, the absence of any effect of supplementary feeding
180 on the numbers of fledglings could be interpreted as evidence of abundant, non-limiting,
181 naturally occurring prey (Martin 1987). This is probable for nests in productive, agricultural
182 landscapes. This is supported by the number of fledglings per pair decreasing significantly as
183 the proportional cover of territories with poor quality habitat increased. Previous
184 supplementary feeding studies have documented earlier laying date and increased clutch size
185 when territory quality is poor (Newton & Marquiss 1981) or when naturally fluctuating prey
186 availability is in a trough year (Dijkstra *et al.* 1982). However, supplementary feeding after egg
187 hatching neutralised this otherwise negative effect reversing the fortunes of Buzzards in the
188 poorest quality territories. The current study, thus, emphasises the importance of food
189 availability when provisioning chicks in sub-optimal habitats.

190 The results of this study suggest that diversionary feeding as a measure to reduce losses of
191 gamebirds to Buzzards is unlikely to dramatically increase Buzzard productivity in areas where
192 prey is not limiting and there is favourable habitat structure. Similarly, productivity is unlikely
193 to be significantly affected by an increase in prey biomass, due to novel prey in south-west
194 Ireland (Rooney & Montgomery 2013, Montgomery *et al.* 2014), or in agricultural areas where
195 prey availability (principally rabbits) is high. However, this may not be the case in sub-optimal
196 habitats (for example, upland grouse moors) where diversionary feeding during the chick-
197 rearing period may be effective in the reduction of predation on Red Grouse *Lagopus lagopus*,
198 but this benefit might be offset due to concomitant increases in Buzzard recruitment (Lees *et*
199 *al.* 2012).

200

201 This study was conducted under licences issued by the Northern Ireland Environment Agency
202 (TSE/21/10; TSE/20/10) and the British Trust for Ornithology (C/5687) and complied with the

203 Queen's University Belfast Ethical Code of Conduct. ER was supported by the Department for
204 Employment and Learning, Northern Ireland (DEL NI). NR was supported by the Natural
205 Heritage Research Partnership (NHRP) between the Northern Ireland Environment Agency
206 (NIEA) and *Quercus*, Queen's University Belfast (QUB). Thanks to David Anderson, Robert
207 Straughan, Kevin Mawhinney and Gillian Riddell for training and field assistance and the
208 Forestry Service NI and landowners for access. Beatriz Arroyo, Sean Walls, Fabrizio Sergio,
209 Antoni Margalida and Jesús Martínez-Padilla provided comments on the manuscript.
210

211 REFERENCES

- 212 **Balmer, D.E., Gillings, S., Caffrey, B.J., Swann, R.L., Downie, I.S. & Fuller, R.J.** (eds). 2013. Bird
213 Atlas 2007–11: the breeding and wintering birds of Britain and Ireland. BTO Books, Thetford.
- 214 **Byholm, P. & Kekkonen, M.** 2008. Food regulates reproduction differently in different habitats:
215 experimental evidence in the Goshawk. *Ecology*. 89: 1696-702.
- 216 **Dijkstra, C., Vuursteen, L., Daan, S. & Masman, D.** 1982. Clutch size and laying date in the kestrel
217 *Falco tinnunculus*: Effects of supplementary food. *Ibis*. 124 (2): 210-213
- 218 **European Environment Agency.** 2010. CORINE Land Cover 2000-2006. Available at:
219 <http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2000-2006>.
- 220 **Gill, V. A. & Hatch, S. A.** 2002. Components of productivity in black-legged kittiwakes *Rissa*
221 *tridactyla*: response to supplemental feeding. *J. Avian Biol.* 33: 113-126.
- 222 **González, L.M., Margalida, A., Sanchez, R., Oria, J.** 2006. Supplementary feeding as an effective
223 tool for improving breeding success in the Spanish imperial eagle (*Aquila adalberti*). *Biol.*
224 *Conserv.* **129**: 477-486.
- 225 **Hardey, J., Crick, H., Wernham, C., Riley, H., Etheridge, B. & Thompson, D.** 2009. *Raptors: A*
226 *field guide for surveys and monitoring*. 2nd ed., Scottish National Heritage: Inverness.
- 227 **Hoyt, D.F.** 1979. Practical methods of estimating volume and fresh weight of birds eggs. *Auk*. 96: 73-
228 77
- 229 **Korpimäki, E. & Wiehn, J.** 1998. Clutch size of kestrels: seasonal decline and experimental evidence
230 for food limitation under fluctuating food conditions. *Oikos* **83**:259-272.
- 231 **Krüger, O.** 2004. The importance of competition, food, habitat, weather and phenotype for the
232 reproduction of Buzzard *Buteo buteo*. *Bird Study*. 51:125-132.
- 233 **Lack, D.** 1954. *The natural regulation of animal numbers*, Clarendon Press, London.
- 234 **Lees, A.C., Newton, I., & Balmford, A.** 2012. Pheasants, buzzards and trophic cascades. *Conserv.*
235 *Lett.* **00**: 1-4.
- 236 **Margalida, A.** 2010. Supplementary feeding during the chick-rearing period is ineffective in increasing
237 the breeding success in the bearded vulture (*Gypaetus barbatus*). *Eur J Wildl Res.* **56**: 673-678.
- 238 **Martin, T.** 1987. Food as a limit on breeding birds: a life-history perspective. *Annu. Rev. Ecol. Syst.*
239 18:453-487.
- 240 **Millon, A., Arroyo, B.E., Brentagnolle, V.** 2008. Variable but predictable prey availability affects
241 predator breeding success: natural versus experimental evidence. *J. Zool.* **275**: 349-358.
- 242 **Montgomery, W.I., Montgomery, S.S.J., & Reid, N.** 2014. Invasive alien species disrupt spatial and
243 temporal ecology and threaten extinction in an insular, small mammal community. *Biol. Invasions*.
244 DOI 10.1007/s10530-014-0717-y.
- 245 **Nager, R.G., Rueger, C., Van Noordwijk, A.J.** 1997. Nutrient or energy limitation on egg formation:
246 a feeding experiment in great tits. *J. Anim. Ecol.* **66**: 495-507.

- 247 **Newton, I. & Marquiss, M.** 1981. Effects of additional food on laying dates and clutch sizes of
248 sparrowhawks. *Ornis Scand.* 12: 224-229
- 249 **Newton, I.** 1998. Population limitation in birds. London, Academic Press.
- 250 **Perrins, C.M.** 1970. The timings of birds' seasons. *Ibis.* 112. 242-255.
- 251 **Robb, G.N., McDonald, R.A., Chamberlain, D.E., Reynolds, S.J., Harrison, T.J. & Bearhop, S.**
252 2008. Winter feeding of birds increases productivity in the subsequent breeding season. *Biol. Lett.*
253 4:220-3.
- 254 **Rooney, E. & Montgomery, W.I.** 2013. Diet diversity of the Common Buzzard (*Buteo buteo*) in a
255 vole-less environment. *Bird Study.* 60: 147-155.
- 256 **Swann, R.L. & Etheridge, B.** 1995. A comparison of breeding success and prey of the Common
257 Buzzard *Buteo buteo* in two areas of northern Scotland. *Bird Study.* 42:37-43.
- 258 **Tubbs, C.** 1974. *The Buzzard.* Newton Abbot: David & Charles.

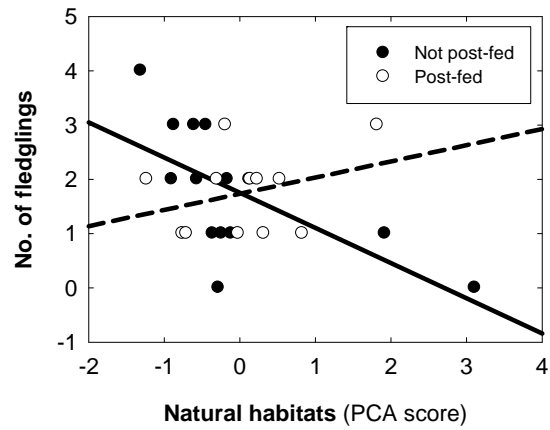


Figure 1. Buzzards nesting in low quality natural habitats e.g. bog, scrub and semi-natural grasslands (i.e. higher principal component scores on the *x*-axis) had fewer fledglings than those nesting in higher quality, agriculture landscapes except if they received supplementary feeding *after* their eggs hatched i.e. post-fed.

Natural habitat PCA scores between treatments

A General Linear Model (GLM) was conducted using the Habitat PCA scores as the dependent variable, assuming a normal distribution (tested for *a priori* using a Kolmogorov-Smirnov test) and an identity link function where there was no difference between scores between buzzard pairs that were Pre-fed and those not pre-fed ($F_{df=1,22} = 1.148, p=0.296$; Fig. S1 *left pair*) or those Post-fed and those not post-fed ($F_{df=1,22} = 0.327, p=0.573$; Fig. S1 *middle pair*) or with the interaction of both two-level factors i.e. the four experimental treatment groups ($F_{df=1,22} = 1.369, p=0.255$; Fig. S1 *right four*). These results were confirmed by non-parametric Mann-Whitney U tests ($U=63, p=0.297$ and $U=106, p=0.274$ respectively) and a Kruskal-Wallis test ($\chi^2_{df=3} = 3.567, p=0.312$). Thus by every measure, Habitat PCA scores were not confounded between the treatment groups.

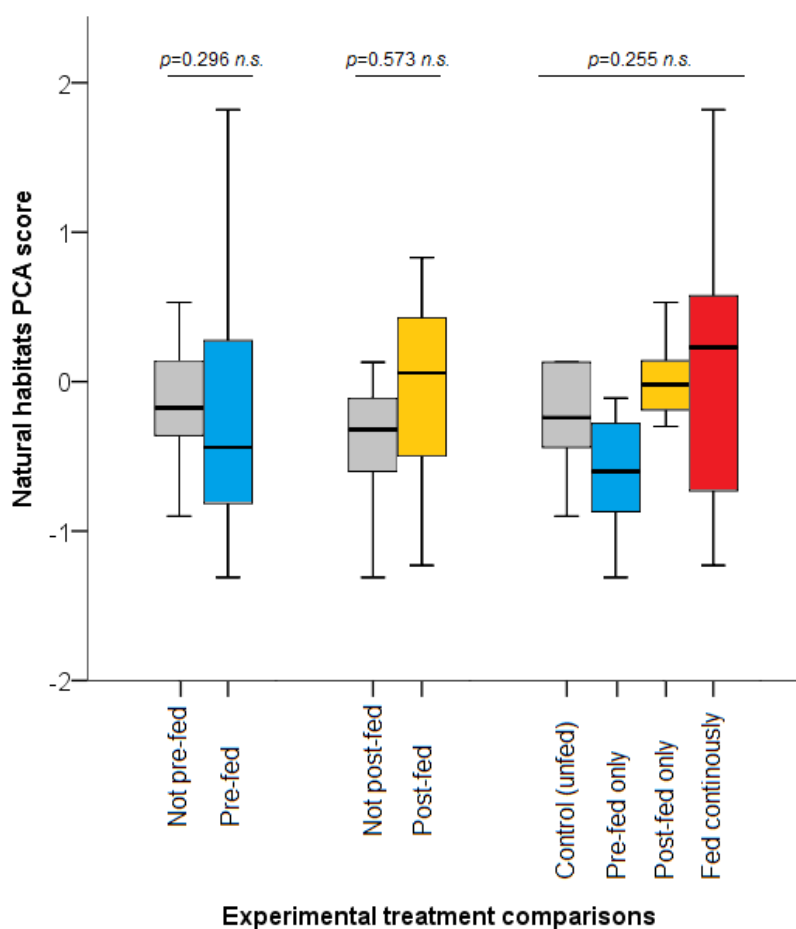


Fig. S1. Boxplot of median Habitat PCA scores between experimental treatment comparison groups.

Table S1. General Linear Models (GLMs) of response variables with experimental treatment and habitat. Significant p -values are shown in bold.

| Model / variables | Distribution | $\beta \pm se$ | n.df. | d.df. | F | P |
|---|---------------------|----------------------------------|--------------|--------------|-----------------------|-----------------------|
| a) Lay Date ($n=21$; 9 pre-fed, 12 control) | | | | | | |
| Pre-fed | Normal | -3.274 ± 2.608 | 1 | 17 | 1.576 | 0.226 |
| Habitat | | 3.270 ± 2.685 | 1 | 17 | 5.423 | 0.032 |
| Pre-fed*Habitat | Factorial | | 1 | 17 | 0.242 | 0.629 |
| b) Clutch size ($n=22$; 9 pre-fed, 13 control) | | | | | | |
| Pre-fed | Poisson | 0.210 ± 0.110 | 1 | 18 | 3.666 | 0.072 |
| Habitat | | 0.043 ± 0.110 | 1 | 18 | 0.001 | 0.972 |
| Pre-fed*Habitat | Factorial | | 1 | 18 | 0.402 | 0.534 |
| c) Egg volume ($n=15$; 4 pre-fed, 11 control) | | | | | | |
| Pre-fed | Normal | 2.678 ± 2.390 | 1 | 11 | 1.256 | 0.286 |
| Habitat | | 2.536 ± 2.812 | 1 | 11 | 2.711 | 0.128 |
| Pre-fed*Habitat | Factorial | | 1 | 11 | 0.005 | 0.947 |
| d) Egg weight ($n=15$; 4 pre-fed, 11 control) | | | | | | |
| Pre-fed | Normal | 0.405 ± 3.418 | 1 | 11 | 0.014 | 0.908 |
| Habitat | | 1.186 ± 4.023 | 1 | 11 | 0.611 | 0.451 |
| Pre-fed*Habitat | Factorial | | 1 | 11 | 0.049 | 0.829 |
| e) Brood size ($n=22$; 9 pre-fed, 13 control) | | | | | | |
| Pre-fed | Poisson | 0.103 ± 0.159 | 1 | 18 | 0.419 | 0.526 |
| Habitat | | -0.310 ± 0.152 | 1 | 18 | 13.552 | 0.002 |
| Pre-fed*Habitat | Factorial | | 1 | 18 | 0.426 | 0.522 |
| f) Hatching success ($n=22$; 9 pre-fed, 13 control) | | | | | | |
| Pre-fed | Normal | -0.091 ± 0.098 | 1 | 18 | 0.875 | 0.362 |
| Habitat | | -0.255 ± 0.101 | 1 | 18 | 17.295 | 0.001 |
| Pre-fed*Habitat | Factorial | | 1 | 18 | 0.073 | 0.790 |
| g) Number of fledglings ($n=26$; 5 pre-fed, 5 post-fed, 7 fed continuously, 9 control) | | | | | | |
| Pre-Fed | Poisson | -0.285 ± 0.279 | 1 | 18 | 3.120 | 0.094 |
| Post-Fed | | 0.662 ± 0.483 | 1 | 18 | 2.811 | 0.111 |
| Pre-Fed*Post-Fed | Factorial | | 1 | 18 | 0.533 | 0.475 |
| Habitat | | -0.216 ± 0.187 | 1 | 18 | 4.373 | 0.051 |
| Pre-fed*Habitat | Factorial | | 1 | 18 | 0.284 | 0.601 |
| Post-fed*Habitat | Factorial | | 1 | 18 | 4.494 | 0.048 |
| Pre-Fed*Post-Fed*Habitat | Factorial | | 1 | 18 | 2.232 | 0.153 |

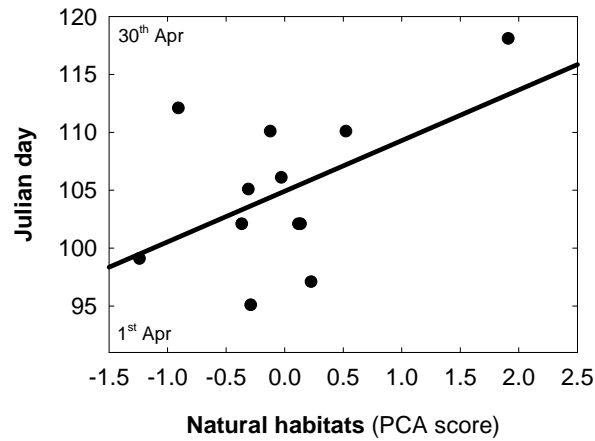


Figure S2. Buzzard pairs nesting in natural habitats (i.e. higher principal component scores on the *x*-axis) laid later than pairs nesting in anthropogenic agricultural landscapes.

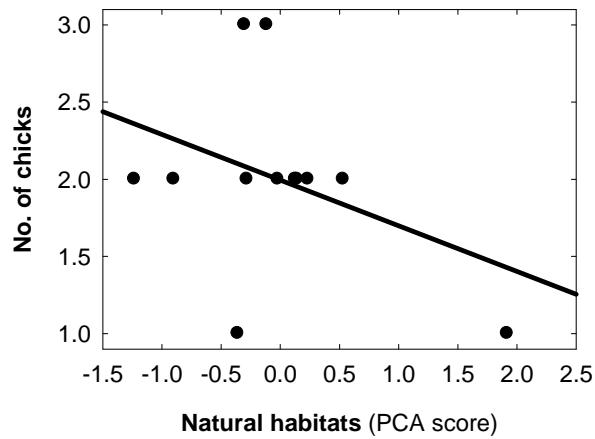


Figure S3. Buzzard pairs nesting in natural habitats hatched fewer chicks than pairs nesting in anthropogenic agricultural landscapes.

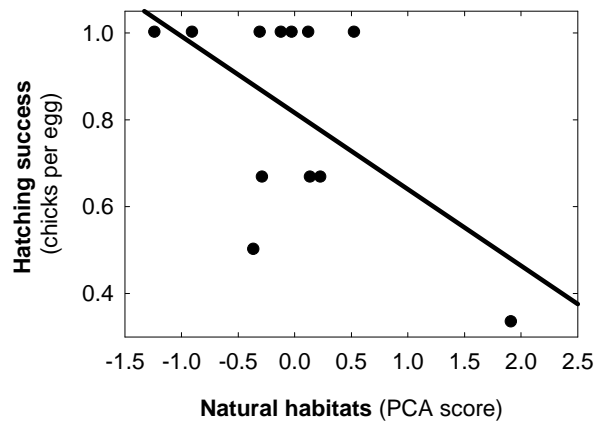


Figure S4. Buzzard pairs nesting in natural habitats had lower hatching success (chicks per egg) than pairs nesting in anthropogenic agricultural landscapes.

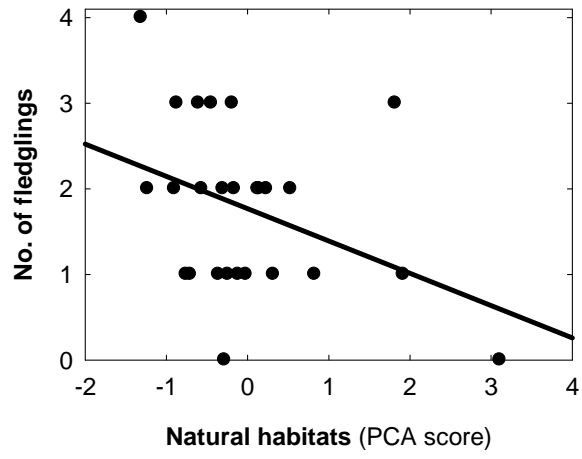


Figure S5. Buzzard pairs nesting in natural habitats had fewer fledglings than pairs nesting in anthropogenic agricultural landscapes.