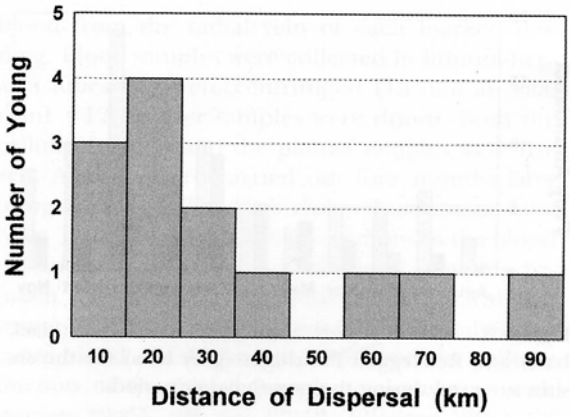

Figure 5. Distribution of dispersal distances for 13 young Bonelli's Eagles based on the first-known roost outside the natal territory in southwestern Spain, 1998.

$N = 11$ and $r_s = -0.03$, $P = 0.92$, $N = 13$, respectively).

Eleven of the 13 instrumented young dispersed to lower elevations. Mean elevation of the first-known roost sites was 281 m lower than nest sites (Wilcoxon paired test, $Z = -2.56$, $P = 0.011$, $N = 13$). Mean direction from the nest to first-known roosts outside the territory was 300.16° (var = 1.21). This direction did not differ from a uniform distribution as determined by the Rayleigh test ($P_{RAY} = 0.13$), modified by Wilkie (1983).

DISCUSSION

The length of the post-fledging period of Bonelli's Eagles was related to hatching date. This period was longer for young that hatched later, which contradicted results of studies on other species (Donázar and Ceballos 1990, Ferrer 1992). For some migratory species, length of the post-fledging period in later-fledged young might be reduced by the need to migrate (Bustamante and Hiraldo 1989, Donázar and Ceballos 1990, Bustamante 1994b). For a nonmigratory species such as the Spanish Imperial Eagle (*Aquila adalberti*), Ferrer (1992) suggested that in addition to physical condition of young, the physical condition of parents may determine the end of the post-fledging period.

Hatching date is generally considered to be a good indicator of territory quality and probably of high food availability (Korpimäki 1987, Cichon and Lindén 1995). Therefore, it seems unlikely that young Bonelli's Eagles that hatched early spent a shorter time in the natal territory as a consequence of food scarcity. The main prey item, both in numbers and biomass, for Bonelli's Eagles in Spain is rabbits followed by Red-legged Partridges (Leiva et al. 1994, Martínez et al. 1994, Real 1996, Ontiveros and Pleguezuelos 2000). As in other Mediterranean ecosystems (Soriguer and Rogers 1981, Beltrán 1991, Villafuerte et al. 1997), our results showed that rabbits and partridges varied seasonally in abundance, with the highest abundance in late spring and late summer. These peaks in rabbit and partridge abundance coincided with the post-fledging period and the initial onset of dispersal of Bonelli's Eagles.

We found a strong negative correlation between temporal abundance of rabbits and length of the post-fledging period. We also found that young that hatched earlier took longer to fledge and had shorter post-fledging periods. This pattern may have been due to the fact that pairs that laid eggs early experienced low rabbit abundance during the brood-rearing period but high abundance during the post-fledging period. In contrast, pairs that laid eggs later in the season experienced high rabbit abundance during the brood-rearing period, but low rabbit abundance during the post-fledging period. Scarcity of rabbits during the latter period could have resulted in young needing more time to reach the necessary body condition for dispersal.

Length of the post-fledging period was directly related to partridge abundance. Therefore, young that fledged later and experienced a scarcity of rabbits would have had access to greater numbers of partridges. These young might have switched from rabbits to partridges thus resulting in the same total length of their post-fledging period as young that fledged earlier. The differences we observed could be explained by the preferences of Bonelli's Eagles for rabbits rather than partridges (Jordano 1981, Leiva et al. 1994, Gil et al. 1994, Ontiveros and Pleguezuelos 2000) that were observed as uneaten remains at nests. The lower biomass of partridges could also have been a factor, but because we assumed the same temporal prey abundance for all sites, we did not know what the real availability of prey was in each territory. There is need for more information on the effects of prey availability and the importance of each prey species on Bonelli's Eagles.

Young Bonelli's Eagles spent most of their time within 3000 m of their nests during the post-fledging period, which is within the estimates of the

mean radius of the natal territory (del Junco 1984, Gil et al. 1996). Distances moved by young from nests increased with age. In the middle of the post-fledging period, these distances increased significantly. Spanish Imperial Eagles exhibit a similar pattern with a significant increase in mobility midway during the post-fledging period when soaring flight starts to occur (Ferrer 1992).

The increase in distance moved from the nest as young aged, and the fact that young suddenly began to disperse, was caused by an increase in hunting effort by the young, as shown by Real et al. (1998), rather than by exploratory behavior or a behavior caused by the parents. Further, we observed no young returning to their natal territory during the first days of dispersal. Siblings seemed to leave territories in an independent manner, suggesting the existence of an endogenous factor to start dispersal. However, our data suggested that the time of dispersal was determined mainly by rabbit availability.

ACKNOWLEDGMENTS

We thank many people for their collaboration in the fieldwork, especially C. Aguilar, C. Fernández, S. Moran, R. Fernández, and J. Ayala. G. Janss and E. Revilla were indispensable for their support. G. Pino arranged a house in the field. F. Recio performed plasma analysis in the Valme Hospital in Sevilla. Special thanks go to R. Villafuerte and G. Jordán. We thank F.M. Jaksic, J.E. Jiménez, and an anonymous referee for their useful comments. This study was directed by M. Ferrer and it was supported by the regional Government (Junta de Andalucía). V. Siebering was funded by the Wageningen University, while E. Mínguez and E. Angulo were funded by the Estación Biológica de Doñana (CSIC).

LITERATURE CITED

BATSCHELET, E. 1981. Circular statistics in biology. Academic Press, London, U.K.

BELTRÁN, J.P. 1991. Temporal abundance pattern of the wild rabbit in Doñana, SW Spain. *Mammalia* 55:591–599.

BUSTAMANTE, J. 1994a. Family break-up in Black and Red Kites *Milvus migrans* and *M. milvus*: is time of independence an offspring decision? *Ibis* 136:176–184.

———. 1994b. Behavior of colonial Common Kestrels *(Falco tinnunculus)* during the post-fledging dependence period in southwestern Spain. *J. Raptor Res.* 28: 79–83.

——— AND F. HIRALDO. 1989. Post-fledging dependence period and maturation of flight skills in the Black Kite *Milvus migrans*. *Bird Study* 36:199–204.

——— AND ———. 1993. The function of aggressive chases by breeding Black and Red Kites *Milvus migrans* and *M. milvus* during the post-fledging dependence period. *Ibis* 135:139–147.

CICHON, M. AND M. LINDÉN. 1995. The timing of breeding and offspring size in Great Tits *Parus major*. *Ibis* 137:364–370.

DEL JUNCO, O. 1984. Estudio sobre una población de águilas perdiceras (*Hieraaetus fasciatus*). *Rapinyaires Mediterranis* II:80–85.

DONÁZAR, J.A. AND O. CEBALLOS. 1990. Post-fledging dependence period and development of flight and foraging behaviour in the Egyptian Vulture *Neophron percnopterus*. *Ardea* 78:387–394.

ELLEGREN, H. 1996. First gene on the avian W chromosome (CHD) provides a tag for universal sexing of non-ratite birds. *Proc. R. Soc. Lond. B.* 263:1635–1641.

FERRER, M. 1990. Hematological studies in birds. *Condor* 92:1085–1086.

———. 1992. Regulation of the period of postfledging dependence in the Spanish Imperial Eagle *Aquila adalberti*. *Ibis* 134:128–133.

———. 1993. Ontogeny of dispersal distances in young Spanish Imperial Eagles. *Behav. Ecol. Sociobiol.* 32:259–263.

GIL, J.M., F.M. MOLINO, AND G. VALENZUELA. 1994. Parámetros reproductivos y alimentación del águila real (*Aquila chrysaetos*) y del águila perdicera (*Hieraaetus fasciatus*) en la Provincia de Granada. *Aegypius* 12:47–51.

———, F.M. MOLINO, AND G. VALENZUELA. 1996. Selección de hábitat de nidificación por el águila perdicera (*Hieraaetus fasciatus*) en Granada (SE de España). *Ardeola* 43:189–197.

HOLEKAMP, K.E. 1986. Proximal causes of natal dispersal in Belding's ground squirrels (*Spermophilus beldingi*). *Ecol. Monogr.* 56:365–391.

HOWARD, W.E. 1960. Innate and environmental dispersal of individual vertebrates. *Am. Midl. Nat.* 63:152–161.

JACOB, E.M., S.D. MARSHALL, AND G.W. UETZ. 1996. Estimating fitness: a comparison of body condition indices. *Oikos* 77:61–67.

JORDANO, P. 1981. Relaciones interespecíficas y coexistencia entre el águila real (*Aquila chrysaetos*) y el águila perdicera (*Hieraaetus fasciatus*) en Sierra Morena central. *Ardeola* 28:67–88.

KENNEDY, P.L. AND J.M. WARD. 1995. Postfledging movements of the Northern Goshawk in northcentral New Mexico. *J. Raptor Res.* 29:43.

KENWARD, R.E. 1987. Wildlife radio tagging. Academic Press, London, U.K.

———, V. MARCSTROM, AND M. KARLBOM. 1993. Post-nestling behaviour in goshawks, *Accipiter gentilis*: the causes of dispersal. *Anim. Behav.* 46:365–370.

KORPIMÄKI, E. 1987. Timing of breeding of Tengmalm's Owl *Aegolius funereus* in relation to vole dynamics in western Finland. *Ibis* 129:58–68.

KREBS, J.R. AND G.R. SINGLETON. 1993. Indices of condition for small mammals. *Aust. J. Zool.* 41:317–323.

LEIVA, A., G. PAREJA, AND J. ARAGONÉS. 1994. Alimentación del águila perdicera (*Hieraäetus fasciatus*) en la Provincia de Córdoba. *Aegypius* 12:15–21.

MARTÍNEZ, J.E., M.A. SÁNCHEZ, D. CARMONA, AND J.A. SÁNCHEZ. 1994. Régime alimentaire de l'Aigle de Bonelli *Hieraatus fasciatus* durant la période de l'élevage des jeunes (Murcia, Espagne). *Alauda* 62:53–58.

MORVAN, R. AND F. DOBCHIES. 1990. Dépendence de jeunes aigles de Bonelli *Hieraaetus fasciatus,* apres l'envol: variations individuelles. *Alauda* 58:150–162.

NORUSIS, M.J. 1992. SPSS for Windows. Base system user's guide. Release 5.0, Chicago, IL U.S.A.

ONTIVEROS, D. AND J.M. PLEGUEZUELOS. 2000. Influence of prey densities in the distribution and breeding success of Bonelli's Eagles (*Hieraaetus fasciatus*): management implications. *Biol. Conserv.* 93:19–25.

REAL, J. 1996. Biases in diet study methods in the Bonelli's Eagle. *J. Wildl. Manage.* 60:632–638.

———, S. MAÑOSA, AND J. CODINA. 1998. Post-nestling dependence period in the Bonelli's Eagle *Hieraaetus fasciatus. Ornis Fenn.* 75:1–9.

REIST, J.D. 1985. An empirical evaluation of several univariate methods that adjust for size variation in morphometric data. *Can. J. Zool.* 62:1429–1439.

SORIGUER, R.C. AND P.M. ROGERS. 1981. The European wild rabbit in Mediterranean Spain. Pages 600–613 *in* K. Myers and C.D. Macinnes [EDS.], Proceedings of the world lagomorph conference. University of Guelph, Guelph, Ontario, Canada.

TORRES, J.A., P. JORDANO, AND A. LEÓN. 1981. Aves de presa diurnas de la provincia de Córdoba. Publicaciones del Monte de Piedad y Caja de Ahorros de Córdoba, Madrid, Spain.

TRIVERS, R.L. 1974. Parent-offspring conflict. *Am. Zool.* 14:249–264.

TUCKER, G.M. AND M.F. HEATH. 1994. Birds in Europe, their conservation status. Cambridge Univ. Press, Cambridge, U.K.

UPTON, G. AND B. FINGLETON. 1989. Spatial data analysis by example. Vol. 2. Categorical and directional data. John Wiley and Sons Ltd., Chichester, U.K.

VILLAFUERTE R., M.B. KUFNER, M. DELIBES, AND S. MORENO. 1993. Environmental factors influencing the seasonal daily activity of the European rabbit (*Oryctolagus cuniculus*) in a Mediterranean area. *Mammalia* 57:341–347.

———, A. LAZO, AND S. MORENO. 1997. Influence of food abundance and quality on rabbit fluctuations: conservation and management implications in Doñana National Park (SW Spain). *Rev. Ecol. (Terre Vie)* 52:345–356.

WALKER, D.G. 1988. The behaviour and movements of a juvenile Golden Eagle *Aquila chrysaetos* in England in 1986. *Ibis* 130:564–565.

WASER, P.M. 1985. Does competition drive dispersal? *Ecology* 66:1171–1175.

WILKIE, D. 1983. Rayleigh test for randomness of circular data. *Appl. Stat.* 32:311–312.

WOOD, P.B., M.W. COLLOPY, AND C.M. SEKERAK. 1998. Postfledging nest dependence period for Bald Eagles in Florida. *J. Wildl. Manage.* 62:333–339.

Received 27 July 2000; accepted 7 April 2001

ERRATUM

J. Raptor Res. 36(2):157

FACTORS INFLUENCING LENGTH OF THE POST-FLEDGING PERIOD AND TIMING OF DISPERSAL IN BONELLI'S EAGLE (*HIERAAETUS FASCIATUS*) IN SOUTHWESTERN SPAIN

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Figures 1 and 3 printed in the article "Factors influencing length of the post-fledging period and timing of dispersal in Bonelli's Eagle (*Hieraaetus fasciatus*) in southwestern Spain," (*Journal of Raptor Research* 35[3]:228–234) were incorrect, draft versions. The correct, revised figures that correspond to this article and that should be substituted for Figure 1 (page 229) and Figure 3 (page 231) are printed below.

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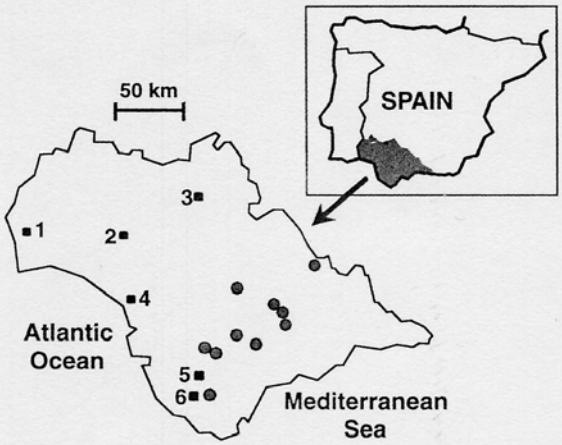

Figure 1. Study area in southwestern Spain, 1998. Grey circles represent the ten territories of Bonelli's Eagles, and numbered black squares are the six sites of prey availability counts.

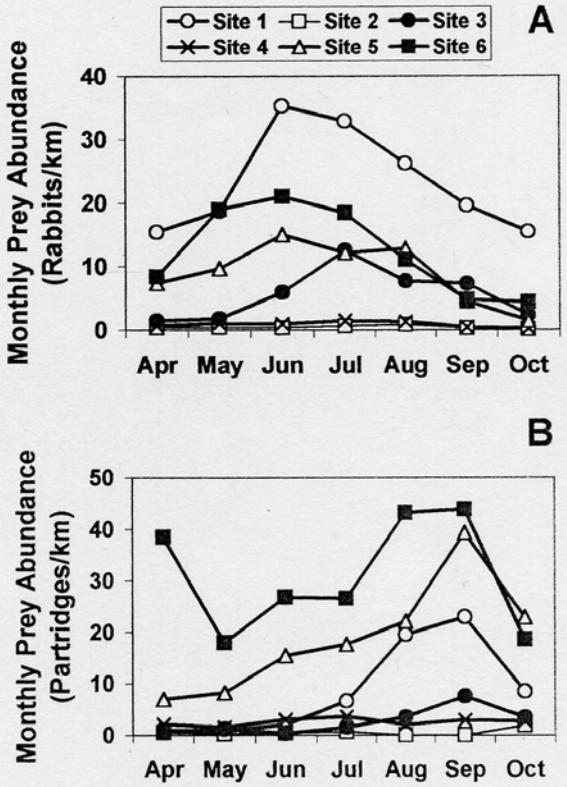

Figure 3. Monthly prey abundance for the six surveyed sites (see Fig. 1 for the geographic locations) during the post-fledging period. (a) European rabbit (*Oryctolagus cuniculus*) abundance. (b) Red-legged Partridge (*Alectoris rufa*) abundance.