J. Raptor Res. 36(2):115–120

SPRING MIGRATION OF ADULT AND IMMATURE BUZZARDS (*BUTEO BUTEO*) THROUGH ELAT, ISRAEL: TIMING AND BODY SIZE

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ABSTRACT.—More than 300 000 Common Buzzards (*Buteo buteo*), particularly steppe buzzards (*B. b. vulpinus*), are counted at the northern end of the Gulf of Aqaba (a.k.a. Gulf of Elat) each spring (Shirihai et al. 2000). In 1996–2000 we captured, banded, and measured 1420 of these northbound migrants at a trapping station north of the city of Elat, Israel. We used information collected from these birds, together with information from 1472 individuals that had been trapped in 1984–88 (Gorney and Yom-Tov 1994) to examine migration timing and body sizes in juvenile (i.e., first-time spring migrants) versus adult migrants at the site. Almost all migrants trapped (>98%) were considered to be steppe buzzards by plumage; 65% were juveniles. The median date of passage for adults (9 April) preceded that of juveniles (26 April) by more than two weeks. Within both age classes, both wing chord and body mass declined significantly with date of capture. Gorney and Yom-Tov (1994) demonstrated that once they had taken overall size into account, juvenile migrants weighed less than did adult migrants. Of the birds trapped, 6.2% had oiled or tarred feathers or toes. A significantly higher proportion of juveniles than adults were oiled or tarred. Our results, together with those of Gorney and Yom-Tov (1994), lead us to conclude that juveniles on their first spring passage are less efficient migrants than are adults, and that they are more likely to succumb to both natural and human-related risks en route.

KEY WORDS: *Common Buzzard;* Buteo buteo; *spring migration; age differences; Elat.*

Migracion primaveral de Gavilanes (*Buteo buteo*) adultos e inmaduros a traves de Elat, Israel: tiempo y tamaño de cuerpo

RESUMEN.—Mas de 300 000 gavilanes comunes (*Buteo buteo*) particularmente de gavilanes de estepa (*B. b. vulpinus*), son contados en el limite norte de el golfo de Agaba (a.k.a. Golfo de Elat) cada primavera (Shirihai et al. 2000). En 1996–2000 capturamos, colocamos bandas y medimos 1420 de estos emigrantes norteños en una estación de trampeo al norte de la ciudad de Elat, Israel. Usamos información colectada a partir de estas aves, junto con información de 1472 individuos que habían sido atrapados en 1984–88 (Gorney and Yom-Tov 1994) para examinar el tiempo de migración y el tamaño del cuerpo en juveniles (p. ej., emigrantes de primavera primerizos) versus adultos migratorios en el sitio. Casi todos los emigrantes atrapados (>98%) se consideraron como migrantes de la estepa debido a su plumaje; 65% eran juveniles. La fecha promedio de paso para los adultos (9 de abril) precedió a la de los juveniles (26 de abril) por mas de dos semanas. Dentro de ambas clases de edad, tanto la cuerda alar como la masa corporal declinó significativamente con la fecha de la captura. Gorney y Yom-Tov (1994) demostraron que una vez ellos hubieron tomado en cuenta el tamaño en conjunto, los juveniles pesaron menos que los adultos migratorios. De las aves atrapadas, 6.2% habian aceitado o alquitranado las plumas o los pies. Una proporción significativamente más alta de juveniles que de adultos se habían aceitado. Nuestros resultados, junto con los de Gorney and Yom-Tov (1994), nos lleva a concluir que los juveniles en su primera travesía de primavera son unos emigrantes menos eficientes que los adultos, y que probablemente ellos sucumben tanto a amenazas naturales como humanas en la ruta.

[Traducción de César Márquez]

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The Common Buzzard (*Buteo buteo*) is a widespread breeder in Europe, Asia, and Africa. The major palearctic subspecies (of 11 described) are *B. b. buteo* (western Europe), *B. b. vulpinus* (Scandinavia east to Siberia: ca. 96°E), *B. b. menetriesi* (between the Black and Caspian seas), and *B. b. japonicus* (east Asia) (Snow and Perrins 1998). Scandinavian, Russian, and most Asian populations, which are strongly migratory, winter in southern Asia, the Middle East, and sub-Saharan Africa (Shirihai et al. 2000).

In Israel, which is a major migratory bottleneck for soaring migrants that breed in Europe and Asia and that over-winter in Africa (Zalles and Bildstein 2000), *B. b. vulpinus* is an abundant migrant in both spring and autumn (Shirihai et al. 2000). Visible migration surveys since 1977 suggest that Elat, at the southernmost tip of Israel, is an important stopover site for the species in spring. The site is at the northern edge of almost 2000 km of contiguous Sahara and Sinai desert, and in spring many northbound migrants land there to rest and roost after crossing the desert (Safriel 1968). We have trapped, banded, and measured large numbers of Common Buzzards at and around Elat in spring (mid-April–early May) 1996–2000. Here, we use the results of those efforts, together with data from an earlier program in 1984–88 (Gorney and Yom-Tov 1994, Gorney et al. 1999), to assess the extent to which immatures and adults differ in the timing of their spring migration.

STUDY AREA AND METHODS

Common Buzzards were caught and banded immediately to the north of Elat, Israel (29°33′N, 34°57′E), both at a permanent banding station in the agricultural fields of Kibbutz Elat using bow-nets, mist nets, and dho-gazas operated from two blinds (Clark 1970, 1981, Clark et al. 1986, Gorney et al. 1999), in box traps in date palm plantations (Clark and Yosef 1997), and from moving vehicles using bal-chatri traps (Berger and Mueller 1959).

All captured raptors were identified to species, aged, measured (unflattened wing chord), and weighed, and then fitted with appropriately-sized, numbered aluminum bands issued by Tel Aviv University. Common Buzzards were aged based on plumage, molt, and iris color (Clark and Yosef 1998). The length of the culmen, hallux, and tail also was noted for some birds. Common Buzzards were assigned to subspecies based on diagnostic plumages and measurements (Cramp and Simmons 1980, Shirihai and Doherty 1990, Shirihai and Forsman 1991, Clark 1999, Forsman 1999). We assumed 1:1 sex ratios in both juvenile and adult buzzards for purposes of age-class analyses and comparisons.

None of the measurements were distributed normally (Kolmogorov-Smirnov test, $P < 0.05$ in all cases). Therefore, we used a nonparametric Mann-Whitney group test to compare age groups (Zar 1984). Even so, unless otherwise stated, all measured data are presented as mean ±SD, N, and range. We chose $P = 0.05$ as the minimum acceptable level of significance.

Data Collection. Data were collected in 1984–88 (Gorney and Yom-Tov 1994, Gorney et al. 1999) as part of a joint raptor trapping and ringing project of the Society for Protection of Nature in Israel and the International Birding and Research Centre in Elat (IBRCE). Data collection, which was reinitiated in 1996 by the IBRCE, continued through 2000 (Clark and Yosef 1997, Shirihai et al. 2000).

RESULTS

Of 2892 Common Buzzards trapped and banded in 1984–88 and 1996–2000, 1880 (65%) were second-year (immature) individuals, and 1012 (35%) were after-second-year (adult) individuals. Ten buzzards that were not aged were not included in the analysis. The ratio of immature to adult birds (1.9:1) differed significantly from 1:1 ($\chi^2 = 129.7$, df = 1, $P < 0.0001$).

Almost all of the buzzards captured (2612; >90.3%) were considered to be steppe buzzards (*B. b. vulpinus*). *B. b. menetriesi* (27; 0.9%) and nominate Common Buzzards (*B. b. buteo*) (8; 0.3%), also were caught. Adult buzzards migrated significantly earlier than immatures (median day-of-year = 99 [9 April in non-leap years] versus 116 [26 April; Fig. 1]); median test, $\chi^2 = 385.3$, df = 1, $P < 0.0001$).

Immatures had significantly longer tails and total body lengths than did adults (Table 1). Within individuals, all paired body measurements were significantly correlated ($r > 0.42$ and $P < 0.01$ in all cases). With this in mind, we chose wing chord as

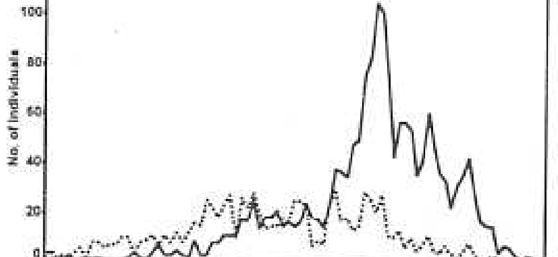

Figure 1. Phenology of migrating buzzards at Elat, Israel, as depicted from banding data. Data represent means for all years 1984–98, 1996–2000. Dashed line denotes adults and solid line immatures.

Table 1. Biometrics of adult and immature steppe buzzards banded in Elat, Israel, in 1984–88 and 1996–2000.

MEASUREMENT	N	IMMATURE MEAN ± SD	N	ADULTS MEAN ± SD	Z VALUE
Body mass	1695	526 ± 75	882	578 ± 87	−14.26
Wing chord	1709	358 ± 15	906	365 ± 15	−10.13
Wingspread	810	1155 ± 43	364	1171 ± 50	−6.13
Culmen	936	21.1 ± 1.3	410	21.5 ± 1.4	−4.66
Tail	1073	189 ± 11	503	185 ± 10	−6.07
Hallux	941	21.3 ± 1.4	413	21.7 ± 1.6	−4.45
Body length	802	432 ± 20	362	429 ± 20	−2.33

All differences significant at $P < 0.001$, except body length where $P = 0.02$.

the parameter representing body size because it had the highest repeatability of features we measured, and because a Principal Component Analysis with Varimax rotation (Sokal and Rohlf 1995) indicated that although all body measurements were included in Principal Component 1, only wing chord had an eigen value higher than 1.0 (3.99), and because wing chord alone explained 57% of the variance in total body size.

A total of 73 buzzards were found dead in the area between 1996–2000. Of these, the majority were juveniles (68; 93%) and only five (7%) adults. Given the overall banding ratio, a significantly greater proportion of juveniles were found dead than banded ($\chi^2 = 25.3$, df = 1, $P < 0.0001$).

Wing Length and Body Mass in Relation to Date of Passage. Overall, wing chord decreased significantly with the date of arrival ($r = -0.164$, $P < 0.0001$, $N = 2615$), and differences were significant in both age classes (Fig. 2). Also, body mass changed significantly with date of passage ($r = -0.354$, $P < 0.0001$, $N = 2577$), and decreases were significant in both age classes (Fig. 3).

DISCUSSION

In many raptors, adults migrate earlier in spring than do juveniles (Newton 1979, Christensen et al. 1981, Kerlinger 1989, Gorney and Yom-Tov 1994). With an overall 10-yr median trapping date of 9 April for adults versus 26 April for juveniles, our results, which extend an earlier 5-yr study of Gorney and Yom-Tov (1994), confirm that Common Buzzards in Israel exhibit age-related differences in the timing of migration. Although a bias is known to occur in trapping of migratory raptors (Nass 1964, Weatherhead and Greenwood 1981), including of steppe buzzards at Elat (Gorney and Yom-tov 1994), we do not consider this to be a parameter that influences this conclusion because visual migration surveys have, independently of the trapping program, confirmed that adults migrate earlier than juveniles (Shirihai 1996, Shirihai and Christie 1992, Shirihai et al. 2000, Yosef 1996).

Although age differences in raptor migration are not completely understood, previous work suggests that such differences occur because (1) breeding

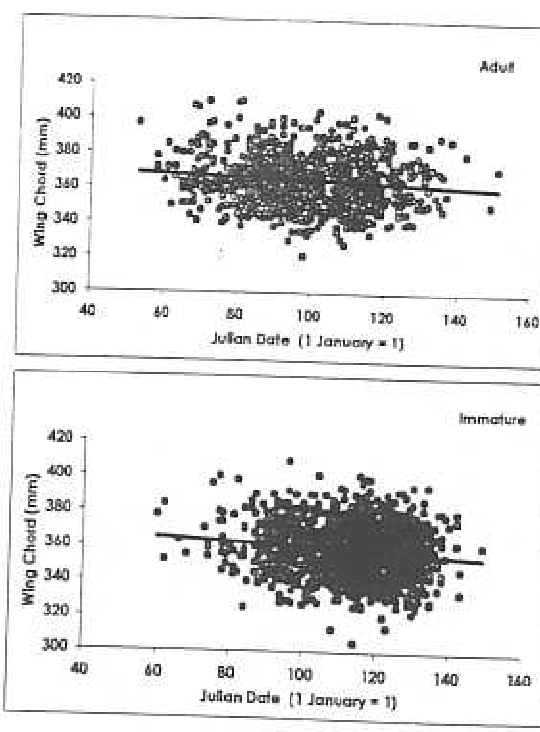

Figure 2. Wing length of adult ($r = -0.083$, $P = 0.012$, $N = 906$; regression y = −0.078 (±0.031) − 0.083; top) and immature ($r = -0.087$, $P < 0.003$, $N = 1709$; regression y = −0.108 (±0.030) − 0.087; bottom) buzzards in relation to date of passage and trapping at Elat.

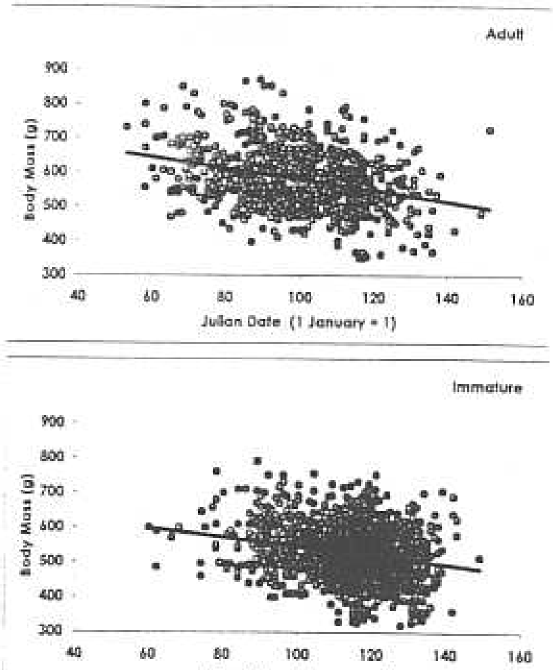

Figure 3. Body mass of adult ($r = -0.307$, $P < 0.0001$, $N = 882$; regression $y = -1.616\ (\pm 0.169) - 0.307$; top) and immature ($r = -0.215$, $P < 0.0001$, $N = 1695$; regression $y = -1.311\ (\pm 0.144) - 0.215$; bottom) buzzards in relation to date of passage and trapping at Elat.

pressures on adults select for earlier arrival on the breeding grounds (Newton 1979, Gorney and Yom-Tov 1994), (2) immatures require more time either to initiate or complete their journeys (Gorney and Yom-Tov 1994), or (3) immatures over-winter farther from their breeding grounds than do adults (Król 1983). The three hypotheses are not mutually exclusive.

In an earlier paper, Gorney and Yom-Tov (1994) argued the earlier passage of adults at Elat suggested that adults were "time selected" migrants, whereas juveniles were "energy-selected" migrants. Their reasoning was based on the fact that because most second-year birds do not breed, they would not need to reach their "breeding grounds" as early in spring as adults, who were returning to breed. We offer an alternative explanation: adults precede juveniles because they are better able to prepare for migration and, therefore, start earlier, are more capable, and are faster migrants en route.

Although their general habitats are reasonably "well known," steppe buzzards have yet to be studied in detail on their wintering grounds in Africa (Brown et al. 1982). Even so, there are suggestions that adults both arrive and leave slightly earlier than immatures (Broekhuysen and Siegfried 1970, Schmidt et al. 1980). This, together with the fact that adults arrive in Elat earlier, and are heavier than juveniles (Gorney and Yom-Tov 1994), suggests that adults maintain a more positive energy balance than juveniles, rather than that the age classes are using different strategies on migration.

Soaring migrants, including steppe buzzards (Tarboton et al. 1987, Spaar 1997) typically travel in large flocks, presumably because in doing so individuals more quickly locate thermal energy needed to assist their long-distance movements (Kerlinger 1989). Observations in North America suggest that in at least one such species, immatures are less adroit at effective soaring than are adults. At Hawk Mountain Sanctuary in eastern Pennsylvania, young-of-the-year Broad-winged Hawks (*Buteo platypterus*), follow adults into and out of thermals during soaring and gliding flight, significantly more so than vice-versa (Maransky and Bildstein 2001). In addition, observations in both coastal New Jersey and peninsular Florida suggest that immature Broad-winged Hawks are more likely to be affected by wind drift and eventually find themselves off course than are more experienced adults (Hagar 1988, Hoffman and Darrow 1992). Taken together these reports suggest that immature steppe buzzards pass through Elat later than adults because they are less efficient migrants than adults, which also is supported by their lower body masses there each spring (Gorney and Yom-Tov 1994).

Juvenile inefficiencies on migration may also explain an age-related bias in the numbers of "tarred and oiled" birds trapped at Elat. Clark and Gorney (1987) reported that 7% (37 of 516) of the buzzards banded at Elat in 1985 and 1986 had oil and tar residues on their feathers or feet, or both. In a similar study in 1996–2000, we found that 86 (6.2%) of 1389 buzzards banded were tarred or oiled, and that 67 (78%) of the tarred birds were juveniles. Presumably the sources of these contaminants are oil fields in the Sahara and Arabian deserts along the Red Sea south of Elat. Given the overall banding ratio of 1.9:1 juveniles to adults, juveniles seem to be more prone to tarring ($\chi^2 = 6.3$, $df = 1$, $P < 0.05$) than adults, possibly because their migration inefficiencies make them more likely to seek drinking water and, therefore, mistakenly land in pools of spilled oil. Assuming that

(1) spring-migration counts of 350 000 steppe buzzards reported for Elat in Shirihai et al. (2000) represent the minimal numbers of northbound migrants, and (2) contaminant information collected from banded birds reflects the level of occurrence in the migratory population, overall, then more than 22 000 buzzards are contaminated and, presumably, disadvantaged (Clark and Gorney 1987) en route, with the majority being immatures.

Gorney and Yom-Tov (1994) suggest that the large proportion of immatures trapped in Elat resulted from age differences in migration routes as has been reported for several raptor species (Bildstein et al. 1983, Clark 1985, Yosef 1996, Yosef and Alon 1997). This is somewhat difficult to evaluate in the case of the steppe buzzards, however, owing to the fact that only 0.3–0.5% of the birds counted on the visible migration survey in the Elat Mountains are subsequently trapped in the fields north of Elat each spring. Even so, geography in the region (Shirihai et al. 2000, Zalles and Bildstein 2000) suggests that the northern end of the Gulf of Elat serves as a major bottleneck for north bound steppe buzzards returning to their breeding grounds each spring, unless adult steppe buzzards are less likely to be wind drifted east toward Elat, and thus more likely to follow the western shoreline of the Red Sea all the way to the northern end of the Gulf of Suez each spring. However, there is no evidence that the adults are less vulnerable to wind drift than immatures (Shirihai 1996, Shirihai and Christie 1992, Shirihai et al. 2000). It seems reasonable to attribute the 1.9:1 juvenile-to-adult age ratio of trapped birds to the increased vulnerability of stressed immatures to being caught in food-baited traps (Gorney and Yom-Tov 1994). We believe that large numbers of steppe buzzards, particularly immatures, reach Elat in rather poor condition, and that many of these die there, succumbing either to starvation or predation in the area.

In conclusion, we submit that the fact that, within age classes, heavier individuals are trapped early in the season suggests more efficient migrants pass earlier than less efficient migrants.

ACKNOWLEDGMENTS

We thank the organizations and individuals who have helped the IBRCE through the years, William S. Clark (Raptours), Dayton Baker (National Aviary in Pittsburgh), WWF-International, Sir and Lady Kaye, Steve Hoffman (Hawkwatch International), Dr. Gerold Dobler (Swarovski Optics), Earthwatch Institute, The Speers (USA), Mrs. L. Mitchell (UK), and Rafi Saar and Montal (Kibbutz Elat). We thank Joe Jehl and two anonymous reviewers for comments on an earlier version of the manuscript. This is IBRCE research contribution number 30 and Hawk Mountain Sanctuary research contribution number 91.

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Received 30 December 2000; accepted 25 November 2001

Former Associate Editor: Allen Fish