SHORT COMMUNICATION

J. Raptor Res. 45(1):88–92

WIND EFFECTS ON VISIBLE RAPTOR MIGRATION IN SPRING AT THE STRAIT OF MESSINA, SOUTHERN ITALY

MICHELE PANUCCIO[1]
University of Pavia, Dipartimento di Biologia Animale, Via Ferrata 1, 27100 Pavia, Italy
and MEDRAPTORS (Mediterranean Raptor Migration Network) via Mario Fioretti 18, 00152 Rome, Italy

KEY WORDS: *European Honey-buzzard*; Pernis apivorus; *flocking behavior*; *raptor migration*; *water crossing*.

Many species of raptors winter in Africa and breed in central and northern Europe, migrating north in the spring and south in autumn (Gensbøl 1992, Ferguson-Lees and Christie 2001). During their travels, the birds face a natural barrier: the Mediterranean Sea. Due to their morphology, the energy consumption of raptors in powered flight increases disproportionately with body mass. As a result, raptors use different flyways according to their dependence on soaring-gliding flight (Kerlinger 1989, Zalles and Bildstein 2000). Anatomy is not the only factor influencing the decision of whether to cross the sea: weather conditions, experience, body condition, time of day, and flocking behavior may also influence the timing of crossing (for a review, see Kerlinger 1989, Bildstein 2006).

Eagles and Eurasian Buzzards (*Buteo buteo*) avoid crossing the central Mediterranean between North Africa and southern Italy, which would entail a long water crossing (Agostini 2005). Conversely, in spring thousands of European Honey-buzzards (*Pernis apivorus*) cross the Channel of Sicily between Cap Bon Peninsula (Tunisia) and western Sicily, distance of about 150 km (Agostini et al. 2007). The behavior of European Honey-buzzards is intermediate between that of broad-winged raptors such as eagles and *Buteos* and that of relatively long-winged raptors such as *Circus* spp., and although they concentrate at narrow straits and isthmuses, they are able to undertake long powered flights over sea (Agostini et al. 2005, Agostini and Panuccio 2005). Black Kites (*Milvus migrans*) form migratory concentrations between North Africa and southern Italy, funnelling over the Channel of Sicily, whereas *Circus* spp. migrate across a wider expanse, passing also over Malta (Beaman and Galea 1974, Agostini and Duchi 1994, Agostini and Panuccio 2010). The main migratory flow of raptors reaching the continental coast of Italy from Sicily is funnelled through the Strait of Messina, where up to 30 000 raptors per year have been counted (Corso 2001). However, between 3000 and 8000 raptors take a more direct route to the Italian peninsula, bypassing the Strait of Messina and concentrating over the islands of Ustica and Panarea (Panuccio et al. 2004, Agostini et al. 2007, Mellone et al. 2007). Previous studies have focused on the relationship between migratory behavior of European Honey-buzzards and weather conditions at the Strait of Messina (Agostini 1992, Agostini et al. 1994b, 2007).

In this report, I analyze the influence of wind conditions on the migratory patterns of raptors at the Strait of Messina by comparing the migratory passage of European Honey-buzzards and *Circus* spp., the most abundant species reported at the site (Giordano 1991, Corso 2001).

STUDY AREA AND METHODS

Observations were made between 27 March and 31 May 2004 from a migratory observation point located along the continental coast of the strait, at the narrowest point between Sicily and continental Italy (approx. 3 km; Fig. 1). Observers used the same observation point (38°13.56′N, 15°40.08′E), on a hilltop between the villages of Scilla and Villa S. Giovanni at an approximate altitude of 300 m asl, for the entire study period. This area was believed to be the primary flyway for migrating raptors in the area (Agostini 1992, Agostini et al. 1994a, 1994b, 1994c, 1995). Observations were made between 08:00 H and 18:00 H (solar time) for a total of 660 hr (observations were interrupted only in case of heavy rainfall). Two researchers, equipped with 10 × 42 binoculars and 20–60× spotting scopes, observed simultaneously, making scans of the sky with binoculars. Observers recorded species, age and sex classes, flight direction, and flocking behavior.

Meteorological data from the Meteorological Station of Reggio Calabria Airport located on the continental side of the strait 15 km south of the watchpoint was used for comparison to the observation data (www.ilmeteo.it). For the analysis, hourly measures of wind strength and direction were used.

The prevailing wind direction at the Strait of Messina was compared to the migratory passage rates of three categories of raptors: the European Honey-buzzard, *Circus* spp., and the total number of raptors (Accipitriformes). The category of *Circus* spp. included Western Marsh Harriers (*Circus aeruginosus*), Montagu's Harriers (*Circus pygargus*), Pallid Harriers (*Circus macrourus*), and Northern Har-

[1] Email address: panucciomichele@gmail.com

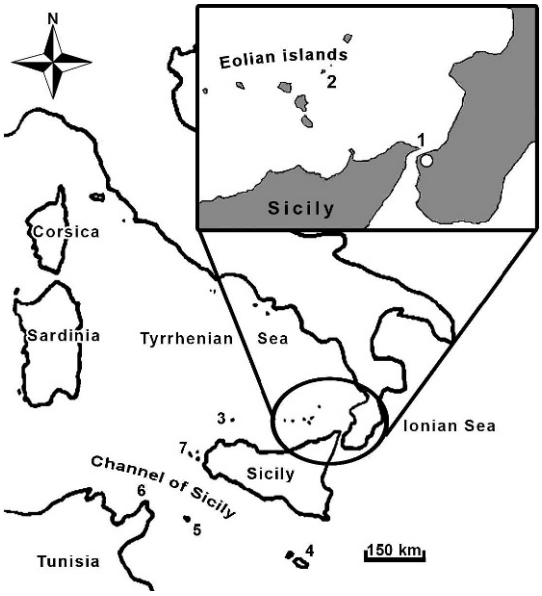

Figure 1. Observation point for monitoring spring raptor migration at the Strait of Messina in southern Italy. Numbers on map denote locations mentioned in the text: (1) Strait of Messina (the white dot indicates the location of observations), (2) island of Panarea, (3) island of Ustica, (4) island of Malta, (5) island of Pantelleria, (6) Cap Bon Promontory, (7) island of Marettimo.

riers (*Circus cyaneus*), analyzed together due to their similar wing morphology and behavior (Kerlinger 1989, Spaar and Bruderer 1997, Meyer et al. 2000). The migration of European Honey-buzzards, the most abundant species observed, was also analyzed in relation to wind speed. The analysis period was limited to 25 April to 31 May for European Honey-buzzards, and from 27 March to 22 May for *Circus* spp., to limit bias due to observations made outside of the migration period.

Other researchers have considered the flock as the sample unit when counting birds crossing water (Agostini et al. 2005, 2007, Panuccio and Agostini 2010). However, in this study, individuals were considered to be the sample unit (see also Agostini 1992). In fact, the behavior of birds funnelling through the straits differs from that of raptors approaching a long water-crossing, because Accipitriformes show a stronger tendency to remain together in front of the water barrier (Kerlinger 1989, Agostini and Duchi 1994, Agostini et al. 2005, Panuccio and Agostini 2010). For this reason, the observed flocking behavior was reported below. I used *t*-tests to compare the mean hourly passage of raptors under the following conditions: headwinds and tailwinds, and weak (<25 km/hr) and strong winds (>25 km/hr). Headwinds and tailwinds categories were defined according to previous researches done in the study area (Agostini 1992, Agostini et al. 2007).

Table 1. European Honey-buzzards and *Circus* spp. observed migrating singly and with other individuals, over the Strait of Messina, Italy, in spring 2004.

	SOLITARY *n* (%)	IN FLOCKS *n* (%)
European Honey-buzzards	266 (3%)	7403 (97%)
Circus spp.	416 (33%)	844 (67%)

RESULTS

Observers counted a total of 9439 raptors of 16 species. Most were European Honey-buzzards (81.2%), Western Marsh Harriers (10.6%) and Black Kites (4.5%). Other species observed were: Montagu's Harrier (187 individuals), Pallid Harrier (26), *Circus pygargus/macrourus* (38), Northern Harrier (7), Eurasian Buzzard (28), Steppe Buzzard (*Buteo buteo vulpinus*; 6), Long-legged Buzzard (*Buteo rufinus*; 2), Booted Eagle (*Hieraaetus pennatus*; 12), Short-toed Snake-Eagle (*Circaetus gallicus*; 3), Golden Eagle (*Aquila chrysaetos*; 1), Egyptian Vulture (*Neophron percnopterus*; 1), Griffon Vulture (*Gyps fulvus*; 1), Eurasian Sparrowhawk (*Accipiter nisus*; 4), Red Kite (*Milvus milvus*; 2), Osprey (*Pandion haliaetus*; 4). In 19 cases it was not possible to identify the species.

Flocking Behavior. European Honey-buzzards (n = 7669) migrated mainly in flocks, averaging 13.1 ± 0.93 (SE) individuals. Only four flocks were observed that contained more than one hundred individuals; one flock, on 11 May, consisted of 506 raptors. In addition, 266 European Honey-buzzards (3.5%) migrated alone.

Harriers migrated in smaller flocks, and a higher percentage migrated alone (contingency table: $\chi^2 = 1585.4$, $P < 0.001$, Table 1). In particular, marsh harriers migrated in small groups averaging 3.5 ± 0.2 birds, with the largest flock containing 34 individuals (observed 2 April). A total of 298 individuals (29.7%) migrated alone.

Of the other *Circus* spp., Montagu's Harriers migrated mostly alone (34.5%) or in small flocks of 2–3 individuals (28.5%). Only two larger flocks were observed: groups of 42 and 28 individuals seen on 17 and 20 April, respectively. All Pallid Harriers were observed migrating alone or in pairs.

Finally, Black Kites primarily migrated in small flocks averaging 3.7 ± 0.2 individuals. One hundred four kites (23.4%) migrated alone.

Movement of raptors at the strait was not homogeneous throughout the day: all three of the most commonly observed species were less frequent during the first two hours of the day (European Honey-buzzard ($\chi^2 = 1151.2$, $P < 0.001$), Western Marsh Harrier ($\chi^2 = 161.5$, $P < 0.001$) and Black Kite ($\chi^2 = 52.7$, $P < 0.01$).

Migration and Wind Conditions. During the observation period (excluding rain hours), the prevailing winds were most frequently from N-NNE (headwind; 325 hr, 56%), and from WSW-SW-SSW (tailwind; 162 hr, 28%). Wind from other directions occurred during only 15% of the

Table 2. Comparison of counts of migrating raptors through the Strait of Messina with headwinds (N-NNE) and tailwinds (WSW-SW-SSW), reported as the hourly mean number of individuals (±SE) and the *P* value of a test for significant differences between the two categories. Dates of observation were 27 March–31 May for all Accipitriformes; 25 April–31 May for European Honey-buzzards; and 27 March–22 May for *Circus* spp.

	ACCIPITRIFORMES		EUROPEAN HONEY-BUZZARDS		*CIRCUS* SPP.	
WIND DIRECTION	HOURLY MEAN	*P*	HOURLY MEAN	*P*	HOURLY MEAN	*P*
Headwind (N-NNE)	24.7 ± 3.4	<0.001	31.4 ± 4.9	0.001	4.2 ± 0.6	<0.001
Tailwind (WSW-SW-SSW)	6.2 ± 1.5		12.3 ± 3.2		0.6 ± 0.1	

hr, and for 8 hr (1%) wind speed was negligible. Winds were considered variable for 0.4% of hr, and data were not available for 0.6% of hr.

The comparison of the mean hourly passage rates of raptors during the two main wind conditions (headwinds and tailwinds) indicated that wind direction influenced the number of raptors seen migrating at the site (Table 2). Considering all individuals of all species ($n = 9439$), a significant higher number passed with headwinds (N-NNE) rather than with tailwinds (WSW-SW-SSW; $t = 5.023$, df = 430.771, $P < 0.001$).

This pattern was true for *Circus* spp. ($t = 6.078$, df = 213.16, $P < 0.001$) and for European Honey-buzzards ($t = 3.293$, df = 277.27, $P = 0.001$). However, on certain days, large numbers of European Honey-buzzards were observed migrating with tailwinds (390, 109, and 126 individuals on 25, 26 and 27 May, respectively). On these days, raptors were observed flying far out over the sea, north of the hawkwatch site.

By contrast, numbers of European Honey-buzzards were not significantly influenced by wind speed (Table 3), either considering all winds regardless of direction ($t = -0.12$, df = 313.18, $P = 0.904$), or only headwinds ($t = 0.294$, df = 207.63, $P = 0.769$).

DISCUSSION

Much previous research, based on both visual observations and on radar detections, has indicated that raptors usually prefer to begin water crossings with tailwinds (Meyer et al. 2000, Agostini et al. 2005, 2007), because tailwinds should allow a faster and energetically less expensive flight over sea. Raptors may also undertake water crossings with lateral winds (Kerlinger 1989, Agostini et al. 1994b), but rarely against strong opposing winds. Meyer et al. (2000) hypothesized that this behavior is adaptive because the risk of exhaustion increases with energy consumption, and therefore risk is higher when flying against headwinds. At the island of Ustica, marsh harriers were observed to begin crossing the Mediterranean Sea mostly when wind speeds were less than 15 km/h, regardless of direction (Panuccio et al. 2002). Considering the increased length of the crossing at that site (250 km), and the associated increase in the risk of changeable weather, it was not surprising that raptors began the long, powered flight from the island only when weather conditions were safer. When tailwinds were blowing, European Honey-buzzards crossing the Mediterranean Sea between Cap Bon and Sicily used a more direct route, when they were observed at the northern side of the Channel of Sicily passing over the island of Marettimo. Conversely, in headwinds or lateral winds, European Honey-buzzards drifted ESE toward the island of Pantelleria where they could use thermal currents to rest from powered flight (Agostini et al. 2007). With tailwinds, a greater number of European Honey-buzzards were observed at the island of Panarea than at the Straits of Messina, although at both sites raptors migrated mostly with headwinds (Agostini et al. 2007).

The results of this study suggest that raptors may concentrate at the Strait of Messina when the weather conditions are not suitable for a longer water crossing, particularly against headwinds. These wind conditions may lead individuals to fly over land where they can exploit thermals, using soaring-gliding flight to minimize the risk and energetic costs of a longer sea crossing. In fact, the short distance of the crossing at the site (about 3 km) allows raptors to reach the continental coast even with strong opposing winds. High numbers of harriers were

Table 3. Numbers of migrating European Honey-buzzards (hourly mean ± SE) relative to wind strength, calculated for all wind directions and for headwinds only (N-NNE), at the Strait of Messina, southern Italy, spring 2004.

WIND DIRECTION		WEAK WINDS <25 km/h	STRONG WINDS >25 km/h	*P*
All directions	Average wind strength (km/h)	16.2 ± 0.5	31.3 ± 0.4	
	Honey-buzzards (hourly mean)	23.3 ± 4.1	24.2 ± 5.1	0.94
Headwinds (N-NNE)	Average wind strength (km/h)	20.7 ± 0.5	31 ± 0.33	
	Honey-buzzards (hourly mean)	32.6 ± 6.8	29.8 ± 6.8	0.769

observed to migrate over Ustica, suggesting that this strategy may be particularly important for harriers, which are more likely to use powered flight than other Accipitriformes (Spaar and Bruderer 1997, Panuccio et al. 2004). Because in other areas raptors fly at specific altitudes in particular wind conditions, I could not exclude the possibility that with tailwinds some raptors may have passed undetected flying at higher altitude (Kerlinger and Gauthreaux 1984, Kerlinger 1989, Panuccio et al. 2010). However, observations made in spring in the central Mediterranean area suggested that European Honey-buzzards tend to fly at a lower altitude with tailwinds (Agostini 1992, Agostini et al. 2005).

Finally, the lower numbers of raptors observed in the early morning hours may be related to the weaker thermal currents in the cool morning; in this case, individuals may choose to bypass the strait and use a more direct route over the sea (see also Agostini et al. 2007). Given the observed flight behavior of raptors in the study area, it is possible that soaring birds will risk collision with the structure of the planned bridge between Sicily and continental Italy. Thus, further investigation of potential mortality risks is recommended.

EFECTOS DEL VIENTO SOBRE LA MIGRACIÓN VISIBLE DE RAPACES EN LA PRIMAVERA EN EL ESTRECHO DE MESSINA, SUR DE ITALIA

RESUMEN.—Se contaron las rapaces migratorias en el estrecho de Messina, el cruce sobre el agua más angosto ubicado entre Sicilia e Italia continental, con el objetivo de investigar la influencia de la dirección y la velocidad del viento sobre el comportamiento de las rapaces que cruzan el estrecho. El estudio fue realizado en la primavera, del 27 de marzo al 31 de mayo de 2004. Los mayores números de rapaces se observaron migrando en el estrecho en días con el viento en contra a la dirección de desplazamiento. La velocidad del viento no afectó el paso de la especie observada con mayor frecuencia, *Pernis apivorus*. Los resultados sugieren que las rapaces típicamente cruzan el mar en el punto más estrecho entre Sicilia y la península italiana cuando las condiciones no son propicias para cruzar un tramo más amplio sobre el agua.

[Traducción del equipo editorial]

ACKNOWLEDGMENTS

This research was financed entirely by NABU (Naturschutzbunde) and Hawk Mediterranean Foundation, in collaboration with the Migration Unlimited Network. I wish to thank Christoph Hein, Antonino Morabito, Djamila Al Albouini, Elena Grasso, Heiko Menz, Andreas Quell, and Bianca Rau for their help during observations. I appreciate the improvements in English usage made by C. Riehl through the Association of Field Ornithologists' program of editorial assistance. I'm grateful to Keith L. Bildstein, Nicolantonio Agostini, Nick Henson, and two anonymous referees for their useful comments on earlier drafts of the manuscript.

LITERATURE CITED

AGOSTINI, N. 1992. Spring migration of honey buzzards (*Pernis apivorus*) at the Straits of Messina in relation to atmospheric conditions. *Journal of Raptor Research* 26:93–96.

———. 2005. Are earlier estimates of Accipitriformes crossing the Channel of Sicily (central Mediterranean) during spring migration accurate? *Journal of Raptor Research* 39:184–186.

———, C. CARDELLI, AND M. GUSTIN. 2007. Factors shaping pathways of European Honey Buzzards (*Pernis apivorus*) during spring migration in the central Mediterranean basin. *Journal of Raptor Research* 41:57–61.

——— AND A. DUCHI. 1994. Water-crossing behavior of Black Kites (*Milvus migrans*) during migration. *Bird Behaviour* 10:45–48.

———, D. LOGOZZO, A. MORABITO, D. MOLLICONE, S. DAVANI, AND O. PFISTER. 1995. La migrazione primaverile dei rapaci Accipitriformi sullo Stretto di Messina. *Avocetta* 19:73.

———, G. MALARA, F. NERI, AND D. MOLLICONE. 1994a. La migrazione primaverile del falco pecchiaiolo, *Pernis apivorus*, sullo Stretto di Messina: problemi di protezione. *Rivista Italiana di Ornitologia* 62:187–192.

———, ———, ———, AND ———. 1994b. La migrazione primaverile del Falco pecchiaiolo (*Pernis apivorus*) a Capo Bon (Tunisia) e sullo Stretto di Messina. Pages 451–452 *in* E. Baldaccini, T. Mingozzi, and C. Violani [EDS.], Atti Museo Regionale Scienze Naturali, Torino, Italy.

———, ———, ———, ———, AND S. MELOTTO. 1994c. Flight strategies of honey buzzards during spring migration across the central Mediterranean. *Avocetta* 18:73–76.

——— AND M. PANUCCIO. 2005. Analysis of the spatial migration patterns of adult honey buzzards (*Pernis apivorus*) during spring and autumn in the central Mediterranean. *Ring* 27:215–220.

——— AND ———. 2010. Western Marsh Harrier (*Circus aeruginosus*) migration through the Mediterranean Sea: a review. *Journal of Raptor Research* 44:136–142.

———, ———, AND B. MASSA. 2005. Flight behaviour of honey buzzards (*Pernis apivorus*) during spring migration over the sea. *Buteo* 14:3–9.

BEAMAN, M. AND C. GALEA. 1974. Visible migration of raptors over the Maltese Islands. *Ibis* 116:419–431.

BILDSTEIN, K.L. 2006. Migrating raptors of the world: their ecology and conservation. Cornell University Press, Ithaca, NY U.S.A.

CORSO, A. 2001. Raptor migration across the Strait of Messina, southern Italy. *British Birds* 94:196–202.

FERGUSON-LEES, J. AND D. CHRISTIE. 2001. Raptors of the world. Houghton Mifflin, Boston, MA U.S.A.

GENSBØL, B. 1992. Guida ai rapaci diurni d'Europa, Nord Africa e Medio Oriente. Zanichelli Editore S.p.A., Bologna, Italy.

GIORDANO, A. 1991. The migration of birds of prey and storks at the Straits of Messina. *Birds of Prey Bulletin* 4:239–249.

KERLINGER, P. 1989. Flight strategies of migrating hawks. University of Chicago Press, Chicago, IL U.S.A.

——— AND S.A. GAUTHREAUX. 1984. Flight behaviour of Sharp-shinned Hawk during migration 1: over land. *Animal Behaviour* 32:1021–1028.

MELLONE, U., N. AGOSTINI, M. PANUCCIO, M. GUSTIN. 2007. La migrazione primaverile dei rapaci Accipitriformi attraverso le isole Eolie: primi dati. Pages 67 *in* CISO [EDS.], Proceedings of the XIV Italian Ornithological Congress, Trieste, Italy.

MEYER, K.S., R. SPAAR, AND B. BRUDERER. 2000. To cross the sea or to follow the coast? Flight directions and behaviour of migrating raptors approaching the Mediterranean Sea in autumn. *Behaviour* 137:379–399.

PANUCCIO, M. AND N. AGOSTINI. 2010. Comparison of the water-crossing behaviour of Western Marsh Harriers (*Circus aeruginosus*) and European Honey Buzzards (*Pernis apivorus*) during autumn migration. *Chinese Birds* 1:30–35.

———, ———, G. LUCIA, U. MELLONE, S. WILSON, J. ASHTON-BOOTH, G. CHIATANTE, AND S. TODISCO. 2010. Local weather conditions affect migration strategies of adult western honey buzzards *Pernis apivorus* through an isthmus area. *Zoological Studies* 49:651–656.

———, ———, AND B. MASSA. 2002. Crossing the Tyrrhenian Sea: spring migration of marsh harriers (*Circus aeruginosus*), sex classes and relation to wind conditions. *Vogelwarte* 41:271–275.

———, ———, AND ———. 2004. Spring raptor migration over Ustica, southern Italy. *British Birds* 97:400–403.

SPAAR, R. AND B. BRUDERER. 1997. Migration by flapping or soaring: flight strategies of marsh, Montagu's and Pallid harriers in southern Israel. *Condor* 99:458–469.

ZALLES, J. AND K. BILDSTEIN. 2000. Raptor watch: a global directory of raptor migration sites. BirdLife Conservation Series No. 9.

Received 4 February 2010; accepted 19 October 2010