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Authors: Choi, Chang-Yong, and Nam, Hyun-Young

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DIET OF PEREGRINE FALCONS (*FALCO PEREGRINUS*) IN KOREA: FOOD ITEMS AND SEASONAL CHANGES

Chang-Yong Choi[1] and Hyun-Young Nam
Migratory Birds Center, Korea National Park Service, Heuksan-myeon, Shinan County, Jeonnam Province 535-917 Republic of Korea

Abstract.—Although the diet of Peregrine Falcons (*Falco peregrinus*) has been studied worldwide, little information on the species' feeding behavior has been reported for East Asia. To document prey composition and seasonal foraging habits, we collected prey remains and observed hunting behavior of Peregrine Falcons from 2001 to 2013 in the Republic of Korea. We identified 362 prey items comprising 77 species, including two insect species, two globally threatened avian species, and three owls. We found wide variation in prey mass, ranging from 0.3 g to 1103 g; the geometric mean prey weight (GMPW) was 128.8 ± 3.5 g, and 74.3% of prey taxa were <240 g in body mass. The diversity and body mass of peregrine prey varied seasonally; peregrines tended to hunt for a few large-bodied prey species in winter when nonbreeding waterbirds were most abundant, whereas they fed on small- to medium-sized birds during other seasons. In particular, peregrines fed on more species in spring and autumn, likely because of the increased diversity and abundance of migratory birds in those seasons. Our results indicated that Peregrine Falcons in Korea show opportunistic food habits, with diet varying according to seasonal prey availability.

Key Words: *Peregrine Falcon*; Falco peregrinus; *diet*; *Korea*; *prey availability*; *seasonal change.*

DIETA DE *FALCO PEREGRINUS* EN COREA: PRESAS Y CAMBIOS ESTACIONALES

Resumen.—Aunque la dieta de *Falco peregrinus* ha sido estudiada en todo el mundo, se ha publicado poca información sobre su comportamiento de alimentación en el este asiático. Para documentar la composición de presas y los hábitos alimentarios estacionales, recolectamos restos de presas y observamos el comportamiento de caza de *F. peregrinus* desde 2001 hasta 2013 en la República de Corea. Identificamos 362 ítems de presas que comprendieron 77 especies, incluyendo dos especies de insectos, dos especies de aves globalmente amenazadas y tres búhos. Encontramos una amplia variación en la masa de las presas, con un rango que va de los 0.3 g hasta los 1103 g; el peso geométrico de presa promedio (PGPP) fue de 128.8 ± 3.5 g y 74.3% de los taxones de presas fue menor a los 240 g en masa corporal. La diversidad y masa corporal de las presas de *F. peregrinus* varió estacionalmente; la especie tendió a cazar pocas especies presa de tamaño grande en el invierno, cuando las aves acuáticas no reproductivas fueron más abundantes, mientras que se alimentó de aves de tamaño pequeño a medio durante otras estaciones. En particular, *F. peregrinus* se alimentó de una mayor diversidad de especies en primavera y otoño, probablemente debido al aumento en la biodiversidad y abundancia de aves migratorias en estas estaciones. Nuestros resultados indicaron que en Corea, *F. peregrinus* evidencia hábitos alimentarios oportunistas, con una dieta que varía de acuerdo con la disponibilidad estacional de presas.

[Traducción del equipo editorial]

The Peregrine Falcon (*Falco peregrinus*) feeds on a wide variety of birds, and hundreds of species have been recorded as prey (Ferguson-Lees and Christie 2001). Although the diet of the Peregrine Falcon has been documented in many areas of its nearly cosmopolitan distribution, little information is available from the northeastern Palearctic (Probst et al. 2007). For example, only a few reports are available from Japan; these describe use of White-cheeked Starlings (*Sturnus cineraceus*; Takenaka and Takenaka 1995), Barn Swallows (*Hirundo rustica*; Kitayama 1996), Brown-eared Bulbuls (*Ixos amaurotis*; Yamada 2011), and unusual prey such as a crab (White et al. 2013). Ishizawa and Chiba (1967) reported that birds were the most common taxa, along with a few insects and mammals, in the stomachs of five peregrines in Japan. Researchers in

[1] Present address: Center for Spatial Analysis, University of Oklahoma, Norman, OK 73019 U.S.A.; email address: subbuteo@hanmail.net

the Russian Far East identified 92 prey items from three nest sites in the Chukotka region (Probst et al. 2007), and shorebirds formed the bulk of prey in Siberia during the breeding season (White et al. 2013). In Taiwan, Huang et al. (2006) reported 44 prey items that emphasized nocturnal hunting behavior. With the exception of anecdotal accounts (e.g., Fennell 1965, Choi et al. 2010, Choi and Nam 2012), the diet of Peregrine Falcons in Korea has never been quantitatively assessed.

Most previous studies on Peregrine Falcon diet in East Asia were based on short-term field observations or opportunistic stomach analyses, and did not investigate prey selection, composition, and seasonal changes. To address the current knowledge gap in this region, we report on the diet of Peregrine Falcons in the Republic of Korea based on field observations and analyses of prey remains over a 10-yr period.

STUDY AREA

To collect information on prey species and seasonal changes, we observed and recorded successful hunting behavior of Peregrine Falcons in the Republic of Korea throughout the year from 2001 to 2013. Field observations were made in known Peregrine Falcon territories, and at wetlands and waterfowl habitats in coastal areas used by Peregrine Falcons in Korea (Fig. 1; Lee et al. 2000). To collect prey remains and pellets, we examined 11 nesting sites in mainland Korea and its associated islands, including Jeju Island (33°22′N, 126°32′E; Fig. 1). In particular, we routinely visited eight active nests and nearby perching sites of Peregrine Falcons on Eocheong-do (36°07′N, 125°58′E), Hong-do (34°41′N, 125°11′E), Heuksan-do (34°41′N, 125°25′E), Chilbal-do (34°47′N, 125°47′E), Gageo-do (34°04′N, 125°07′E), Gugul-do (34°07′N, 125°05′E), Baek-do (34°02′N, 127°35′E), and Mara-do (33°07′N, 126°16′E) islands. Some of the islands contain breeding seabird colonies of Swinhoe's Storm-Petrels (*Hydrobates monorhis*) and murrelets (*Synthliboramphus* spp.).

Two subspecies of the Peregrine Falcon have been recognized in Korea (Ornithological Society of Korea 2009). Only *Falco peregrinus japonensis*, which is commonly distributed in the Russian Far East, Korea, Japan, eastern China, and Taiwan (Brazil 2009, Yamazaki et al. 2012, White et al. 2013), was sampled in our study, because the other subspecies (*F. p. pealei*) is considered a winter vagrant (Brazil 2009, Ornithological Society of Korea 2009).

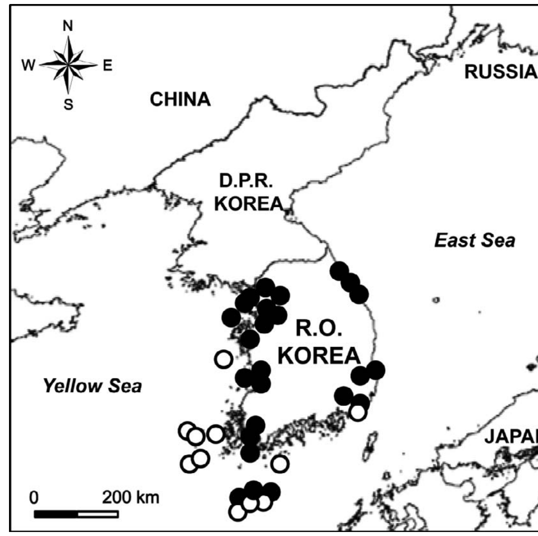

Figure 1. Study areas used in investigation of Peregrine Falcon food habits in the Republic of Korea (open circles: nesting sites; filled circles: non-nesting areas).

METHODS

Data Collection and Prey Identification. Whenever possible, prey were identified based on their morphological features in the field at the time of observation; photographs were used for identification as well. Remains of prey that could not be positively identified in the field were brought to the laboratory and identified by examining the remaining parts such as heads, wings, legs, and feathers; some of the remains were compared to reference collections, live birds in bird banding stations, and to our own specimens from the study areas for identification (Oro and Tella 1995, Ellis et al. 2004). To avoid counting an individual bird twice, we cleaned the prey remains and feathers from the perching site or nests after sample collection, and used only diagnostic parts of prey to conservatively estimate the minimum number of individuals present (Oro and Tella 1995, Ellis et al. 2004, Probst et al. 2007, Olsen et al. 2008, Choi et al. 2010). Because feathers in pellets were typically highly digested and abraded, only a few prey items with unique coloration and marks (such as the Black-naped Oriole [*Oriolus chinensis*]) were recognizable. To minimize bias due to misidentification, only prey items identified to species were included in further analyses. To understand general prey use of Peregrine Falcons in Korea, 32 prey items that we previously reported and identified to species at one of the current study areas (Choi et al. 2010, Choi and Nam 2012) were included in this study to increase the sample size.

Breeding locations of Peregrine Falcons and migration pathways of potential prey species likely affect prey availability and selection. Consequently, to assess temporal patterns in diet we analyzed prey use in four different seasons: spring (breeding period from March to mid-June), summer (post-fledging period from mid-June to August), autumn (September to November), and winter (December to February). Because of the biogeographic location of the Korean Peninsula in the temperate zone of East Asia, a large migration of diverse avian taxa regularly occurs in the range of Peregrine Falcons during spring and autumn (Won et al. 1966, Won et al. 2010, Choi and Nam 2012).

We used binoculars and spotting scopes, often aided by photography with 300- to 800-mm telephoto lenses. Although we made more than 300 field observations and collected 250 prey remains and pellets, we usually kept records only of successfully identified prey. Therefore, a total of 393 samples (181 observation and photo records, 208 prey remains and four pellets) collected through 191 field trips were used for diet analysis in this study (Table 1).

Prey Mass Determination. We captured confirmed or potential prey species, including migratory and resident birds, using mist nets and other methods on islands including Eocheong-do, Hong-do, Heuksan-do and Mara-do. Body mass of the birds was measured using electronic balances to the nearest 0.01 g. We used body mass values reported by Dunning (2008) for species we were unable to capture, and a mean value of the upper and lower limits was used if a mean body mass was not given.

Statistical Analyses. Because prey biomass was not normally distributed, we calculated the geometric mean prey weight (GMPW) by $\log_e$-transformation of the mean masses of individual prey species prior to calculating the grand mean prey mass (Jaksić and Braker 1983, Marti et al. 2007, Olsen et al. 2008, Zuberogoitia et al. 2013) and used the Kruskal–Wallis test (one-way analysis of variance on ranks) followed by pairwise multiple comparison procedures (Dunn's method) to compare GMPWs by season. We used SigmaPlot 12.0 (Systat Software Inc., San Jose, California, U.S.A.) for statistical analysis and data management. All values were presented as mean ± standard deviation (SD).

To understand food habits and seasonal changes, food-niche breadth (FNB) and standardized niche breadth (FNB_{st}) were calculated following Reynolds and Meslow (1984) and Gatto et al. (2005):

$$FNB = 1/\left(\Sigma P_i^2\right), \qquad \text{for i} = 1 \text{ to T}$$

and

$$FNB_{st} = (FNB-1)/(T-1),$$

where P_i is the proportion of prey among species and T is the number of species.

To quantify the similarity of diets between seasons, diet overlap was estimated using Morisita's Index (Morisita 1959), which is considered to be the least biased of the diet overlap estimators (Smith and Zaret 1982):

$$C = 2\,\Sigma\, P_{i1}P_{i2} \Big/ \Big\{\Sigma\, P_{i1}\,[(n_{i1}-1)/(N_1-1)] + \Sigma\, P_{i2}\,[(n_{i2}-1)/(N_2-1)]\Big\},$$

where P_{ij} is the proportion of utilization of prey taxa i used in the season j, n_{ij} is the number of prey taxa i used in the season j, and N_j is the total number of prey used in the season j.

Sampling effort may affect the observed number of Peregrine Falcon prey species; our sampling efforts, the number of field trips on which we collected samples, were not equivalent throughout the seasons (86, 21, 23, and 61 trips in spring, summer, autumn, and winter, respectively; Table 1), resulting in potential biases. To account for potential confounding effects of sampling effort on observed species richness, we compared species richness recorded per 10 field trips among seasons, by computing the number of prey species and its unconditional standard deviation for each field trip through 100 randomizations without replacement in EstimateS 9.1 software (Colwell 2013). We then compared the estimated species richness in the diet of peregrines on a seasonal basis that is free from the bias of different sampling efforts.

RESULTS

We identified 362 prey comprising 77 species, and all were avian prey except two insect species (Table 1; Appendix). By season, 197 individuals of 56 species were recorded from 205 samples in spring, 33 prey items comprising 15 species in 52 summer samples, 51 prey items comprising 29 species in 55 autumn samples, and 81 birds of 22 species from 81 samples in winter (Table 1; Appendix).

Table 1. Sampling effort, collected samples, and identified prey of Peregrine Falcons in Korea.

Samples and Prey	Season				Total
	Spring	Summer	Autumn	Winter	
Sampling effort					
No. of trips	86	21	23	61	191
Collected samples					
Observation	82	35	18	46	181
Prey remains	120	16	37	35	208
Pellets	3	1	0	0	4
Total	205	52	55	81	393
Identified prey					
Prey species	56	15	29	22	77
Prey individuals	197	33	51	81	362

In terms of identified prey species, the most commonly encountered prey were Ancient Murrelet (*Synthliboramphus antiquus*; $n = 34$), Oriental Turtle-dove (*Streptopelia orientalis*; $n = 22$), Japanese Murrelet (*S. wumizusume*; $n = 20$), Eurasian Scaly Thrush (*Zoothera dauma*; $n = 20$), followed by Swinhoe's Storm-Petrel ($n = 15$) and Black-tailed Gull (*Larus crassirostris*; $n = 15$; Appendix). Two globally threatened species on the IUCN red list, Japanese Murrelet and Fairy Pitta (*Pitta nympha*), three owls (Oriental Scops-Owl [*Otus sunia*], Japanese Scops-Owl [*O. semitorques*], and Long-eared Owl [*Asio otus*]) and one nightjar (*Caprimulgus indicus*) were included in the list of prey items.

We documented substantial variation in the body mass and seasonal composition of prey used by Peregrine Falcons. The mean biomass of all prey was 221.9 ± 242.0 g, and most of them (269 of 362 prey; 74.3%) were <240 g (Fig. 2). Excluding two dragonflies, which weighed 0.31 g and 0.63 g, the biomass of avian prey ranged from 11.2 g for Mugimaki Flycatchers (*Ficedula mugimaki*) to 1103.0 g for Herring Gulls (*Larus argentatus*). We observed anecdotally that Peregrine Falcons occasionally attempted to attack larger birds (>1 kg) such as Black-faced Spoonbills (*Platalea minor*; 1228 g) and Grey Herons (*Ardea cinerea*; 1443 g) without success. The geometric mean weights of all prey and verte-

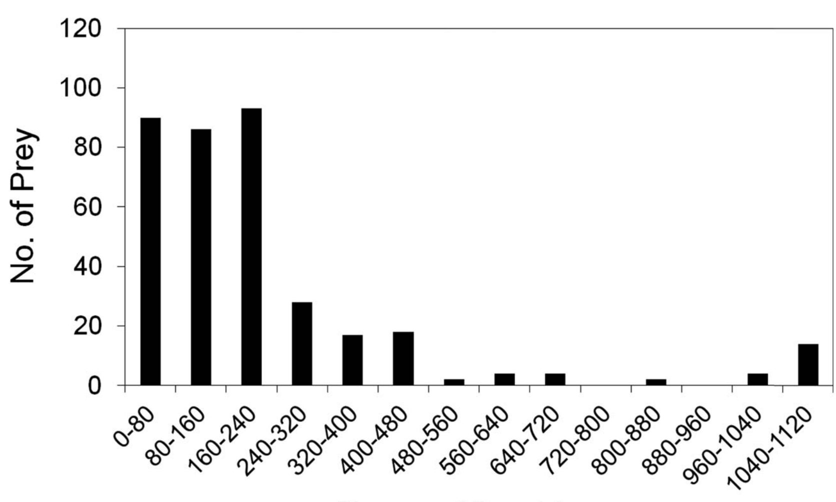

Figure 2. Distribution of 362 prey of Peregrine Falcons by prey biomass in the Republic of Korea from 2001 to 2013.

Table 2. Geometric mean weight of all prey and vertebrate prey of Peregrine Falcons in Korea.

	SEASON				
SAMPLE TYPE	SPRING	SUMMER	AUTUMN	WINTER	OVERALL
All prey	108.8 ± 2.2 g	37.9 ± 8.6 g	105.2 ± 3.2 g	362.8 ± 2.2 g	128.8 ± 3.5 g
Vertebrate prey	108.8 ± 2.2 g	94.2 ± 2.7 g	118.2 ± 3.0 g	362.8 ± 2.2 g	143.3 ± 2.7 g

brate prey were 128.8 ± 3.5 g and 143.3 ± 2.7 g, respectively (Table 2). Seasonal differences were also detected (all prey: df = 3, $H = 96.10$, $P < 0.001$, vertebrate prey: df = 3, $H = 91.00$, $P < 0.001$); in both cases, the GMPW of prey in winter was higher than those in the three other seasons, whereas no differences among the other seasons were noted (Table 2).

We also detected seasonal differences in food-niche breadth and prey diversity. The FNB and FNB_{st} were highest in spring, and lowest in summer (Table 3). Diet overlap was highest between summer and autumn due to the dependence on Swinhoe's Storm-Petrels from July to October, and was also high between winter and spring due to the high use of wintering and breeding murrelets from November to March (Table 4). Species richness in diets, considering the different sampling efforts, differed by season (Fig. 3; df = 3, $H = 171.30$, $P < 0.001$); the estimated number of prey species per 10 field trips was highest in spring (14.10 ± 3.72) and autumn (15.04 ± 6.60), lower in summer (9.19 ± 1.35), and lowest in winter (8.35 ± 1.30).

DISCUSSION

Despite the Peregrine Falcon's consumption of prey ranging from dragonflies or flycatchers to gulls, our data show that the year-round geometric mean prey weight in Korea was only 128.8 to 143.3 g, which was mainly the result of numerous small- to medium-sized birds. This value was similar to the range (132.1 to 140.1 g) reported in Australia (Olsen et al. 2008), and smaller than the value of 169.0 g reported by Jaksić and Braker (1983).

Animal resource selection is commonly described by comparing any two or more of the possible sets of resource units: e.g., used, unused, and available (Manly et al. 2002). Although we could not quantify prey preferences due to a lack of information on overall prey availability or unused prey, commonly taken prey species were abundant residents (e.g., turtle-doves), migratory birds (e.g., thrushes), and colonial seabirds (e.g., murrelets) of the biomass range 100–200 g in this region. The heaviest prey items in our study were Herring Gulls, Mallards, and Chinese Spot-billed Ducks, all of which are at the approximate upper limit (1036–1100 g) for regularly taken prey of Peregrine Falcons (Ellis et al. 2004, Olsen et al. 2008).

In this study, seasonal differences in the diversity and biomass of prey were detected. As Rejt (2001) noted, this difference may be explained by seasonal patterns of bird richness and abundance in typical Peregrine Falcon habitat in Korea: higher prey richness in spring and autumn due to the presence of smaller migratory birds (such as passerines), and lower richness in summer and winter after many of those migrants have passed through or departed from the habitat of peregrines (Won et al. 2010, Choi and Nam 2012). FNB and FNB_{st}, as well as the estimated prey diversity per standardized sampling effort, were also high in spring and autumn, resulting in higher diet overlap between two migratory seasons because peregrines preyed on

Table 3. The number of prey species, food-niche breadth (FNB) and standardized food-niche breadth (FNB_{st}) of Peregrine Falcons in Korea.

	SEASON			
MEASURE	SPRING	SUMMER	AUTUMN	WINTER
No. of prey species	56	15	29	22
FNB	23.23	8.98	14.21	10.84
FNB_{st}	0.29	0.11	0.17	0.13

Table 4. Morisita's Index indicating Peregrine Falcon diet overlap between seasons.

	SEASON			
SEASON	SPRING	SUMMER	AUTUMN	WINTER
Spring	1.000	0.232	0.433	0.452
Summer	–	1.000	0.682	0.103
Autumn	–	–	1.000	0.310
Winter	–	–	–	1.000

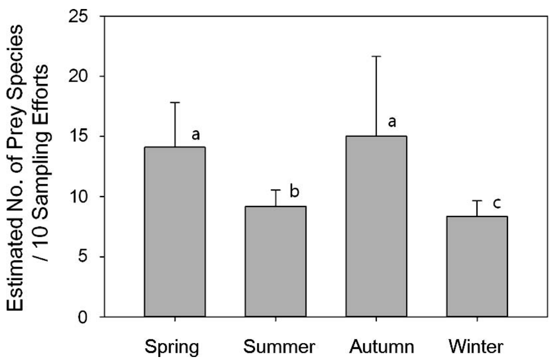

Figure 3. Seasonal change in the estimated prey species richness per 10 sampling efforts to determine the diet of Peregrine Falcons in the Republic of Korea from 2001 to 2013. Bars with different letters are significantly different ($P < 0.05$), and vertical lines denote standard deviations.

commonly occurring migrants. In particular, the higher FNB and FNB_{st} in spring were also likely influenced by the increased energy demands during the nestling-rearing period.

Some bird species occurred as prey seasonally in a repeated and predictable way, supporting the conclusion that peregrines benefited by the routine migration of avian prey, as in previous studies (Rejt 2001, Drewitt and Dixon 2008, Zuberogoitia et al. 2013). For instance, Fairy Pittas and thrushes, although they were common prey in spring and autumn migration periods, were not recorded in summer, when they inhabit forested environments and were therefore much less available to Peregrine Falcons. The peregrine's coastal and island distribution in Korea (Lee et al. 2000) likely influenced the scarcity of Rock Pigeons (*Columba livia*) in the prey samples (3.59% in frequency and 5.77% in biomass); previous studies noted greater representation of this species as a prey item, commonly ranging from 30% to 50%, particularly in the case of urban-dwelling peregrines (Rejt 2001, Serra et al. 2001, Drewitt and Dixon 2008). Because tagged, strayed racing pigeons from China and Taiwan were occasionally found among the prey remains, we believe that some cultural factors, such as the absence of pigeon racing in Korea, likely influence the low occurrence of pigeons in the diet. Three species of true owls (family Strigidae) were identified as Peregrine Falcon prey along with a nocturnal nightjar. Nocturnal hunting by Peregrine Falcons is known (Ratcliffe 1993, Ferguson-Lees and Christie 2001, Huang et al. 2006, Drewitt and Dixon 2008), but the nocturnal birds found in our study may have been vulnerable to attack by Peregrine Falcons if they made a daytime sea-crossing.

Peregrine Falcons in Korea used avian prey almost exclusively, as often noted elsewhere (e.g., Ratcliffe 1993, Bradley and Oliphant 1991, Ferguson-Lees and Christie 2001, Yamazaki et al. 2012, White et al. 2013, Zuberogoitia et al. 2013). However, as Choi and Nam (2012) reported, peregrines also consumed migratory dragonflies on remote islands. Such insects are a minor component of the diet in terms of energy input, but there are many reports of insect-foraging by peregrines (White and Brimm 1990, Ellis et al. 2007, Olsen et al. 2008, Sumner and Davis 2008), particularly when and where large numbers of insects are in flight and they are easily captured (Bradley and Oliphant 1991). Seabirds may form the bulk of prey when peregrines nest near seabird colonies (Beebe 1960, Nelson 1990, Dekker and Bogaert 1997, Probst et al. 2007, White et al. 2013), and we also found that the abundance of prey likely influenced the diet of peregrines in Korea, which may have specialized on colonially breeding seabirds (Ancient Murrelet, Japanese Murrelet, and Swinhoe's Storm-Petrels). This resulted in high values of diet overlap indices between summer and autumn when Swinhoe's Storm-Petrels bred; the high predation rate on oil-contaminated murrelets in winter (Choi et al. 2010) also caused high diet overlap with spring, when peregrines and murrelets bred concurrently.

Peregrine Falcons opportunistically captured a wide range of prey species that reflected seasonal differences in the composition of the local avian community (Serra et al. 2001, Drewitt and Dixon 2008). Our findings suggest that peregrines in Korea forage opportunistically, based on prey size and seasonal availability. Their diet includes abundant and diverse small- to medium-sized migrants in spring and autumn, larger waterbirds in winter, and some colonially breeding seabirds. We also reported a number of previously undocumented prey species for Peregrine Falcons, including Swinhoe's Storm-Petrel and many landbirds (e.g., Narcissus Flycatcher [*F. narcissina*], Siberian Rubythroat [*Luscinia calliope*], Varied Tit [*Parus varius*]) found in East Asia.

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Appendix. Frequency and biomass (g) of 362 prey items of Peregrine Falcons (*Falco peregrinus*) identified from 2001 to 2013 in the Republic of Korea. Percentages by frequency and biomass are presented in parentheses. The mean body mass of prey was calculated from captured live prey in Korea (sample sizes in parentheses); in the absence of such information, masses were taken from Dunning (2008; marked with asterisks).

Prey Item	Mean Body Mass of Prey (g)	Spring (March–Mid-June)		Summer (Mid-June–August)		Autumn (September–November)		Winter (December–February)	
		Frequency	Biomass	Frequency	Biomass	Frequency	Biomass	Frequency	Biomass
BIRDS									
Little Grebe	135.0*	–	–	1	135.0	–	–	2	270.0
Tachybaptus ruficollis				(3.0)	(3.5)			(2.5)	(0.7)
Swinhoe's Storm Petrel	41.7	–	–	5	208.5	10	417.0	–	–
Hydrobates monorhis	(n = 18)			(15.2)	(5.5)	(19.6)	(4.3)		
Yellow Bittern	74	6	444.0	1	74.0	–	–	–	–
Ixobrychus sinensis	(n = 15)	(3.0)	(1.6)	(3.0)	(1.9)				
Schrenck's Bittern	103.4	2	206.8	–	–	–	–	–	–
Ixobrychus eurhythmus	(n = 14)	(1.0)	(0.7)						
Black-crowned Night-heron	383	3	1149.0	1	383.0	–	–	–	–
Nycticorax nycticorax	(n = 1)	(1.5)	(4.2)	(3.0)	(10.0)				
Striated Heron	221.8	–	–	–	–	1	221.8	–	–
Butorides striata	(n = 5)					(2.0)	(2.3)		
Cattle Egret	289.7	4	1158.8	3	869.1	3	869.1	–	–
Bubulcus ibis	(n = 13)	(2.0)	(4.2)	(9.1)	(22.8)	(5.9)	(9.0)		
Mallard	1082.0*	–	–	–	–	–	–	6	6492.0
Anas platyrhynchos								(7.4)	(16.8)
Chinese Spot-billed Duck	1010.5*	–	–	–	–	–	–	4	4042.0
Anas zonorhyncha								(4.9)	(10.4)
Green-winged Teal	239.3	–	–	–	–	2	478.6	6	1435.8
Anas crecca	(n = 6)					(3.9)	(4.9)	(7.4)	(3.7)
Baikal Teal	434.0*	–	–	–	–	1	434.0	1	434.0
Anas formosa						(2.0)	(4.5)	(1.2)	(1.1)
Falcated Duck	649.0*	–	–	–	–	–	–	1	649.0
Anas falcata								(1.2)	(1.7)
Northern Shoveler	613.0*	–	–	–	–	2	1226.0	1	613.0
Anas clypeata						(3.9)	(12.7)	(1.2)	(1.6)
Tufted Duck	701.5*	–	–	–	–	–	–	3	2104.5
Aythya fuligula								(3.7)	(5.4)
Smew	610.0*	–	–	–	–	–	–	1	610.0
Mergellus albellus								(1.2)	(1.6)
Watercock	403.0*	1	403.0	–	–	–	–	–	–
Gallicrex cinerea		(0.5)	(1.5)						

Appendix. Continued.

PREY ITEM	MEAN BODY MASS OF PREY (G)	SPRING (MARCH–MID-JUNE)		SUMMER (MID-JUNE–AUGUST)		AUTUMN (SEPTEMBER–NOVEMBER)		WINTER (DECEMBER–FEBRUARY)	
		FREQUENCY	BIOMASS	FREQUENCY	BIOMASS	FREQUENCY	BIOMASS	FREQUENCY	BIOMASS
White-breasted Waterhen	128	3	384.0	–	–	–	–	–	–
Amaurornis phoenicurus	(n = 2)	(1.5)	(1.4)						
Common Moorhen	154.3	1	154.3	3	462.9	1	154.3	–	–
Gallinula chloropus	(n = 9)	(0.5)	(0.6)	(9.1)	(12.1)	(2.0)	(1.6)		
Eurasian Coot	836.0*	–	–	–	–	–	–	2	1672.0
Fulica atra								(2.5)	(4.3)
Dunlin	57.6*	5	288.0	–	–	–	–	1	57.6
Calidris alpina		(2.5)	(1.0)					(1.2)	(0.1)
Grey-tailed Tattler	127.0*	1	127.0	–	–	–	–	–	–
Tringa brevipes		(0.5)	(0.5)						
Common Sandpiper	48.0*	2	96.0	–	–	–	–	–	–
Actitis hypoleucos		(1.0)	(0.3)						
Black-tailed Godwit	291.0*	–	–	–	–	2	582.0	–	–
Limosa limosa						(3.9)	(6.0)		
Eurasian Woodcock	306.0*	1	306.0	–	–	–	–	–	–
Scolopax rusticola		(0.5)	(1.1)						
Common Snipe	80.8	1	80.8	–	–	–	–	–	–
Gallinago gallinago	(n = 50)	(0.5)	(0.3)						
Black-winged Stilt	161.0*	3	483.0	–	–	–	–	–	–
Himantopus himantopus		(1.5)	(1.7)						
Red-necked Phalarope	36.8*	2	73.6	–	–	–	–	–	–
Phalaropus lobatus		(1.0)	(0.3)						
Black-headed Gull	284.0*	1	284.0	–	–	2	568.0	2	568.0
Larus ridibundus		(0.5)	(1.0)			(3.9)	(5.9)	(2.5)	(1.5)
Herring Gull	1103.0*	–	–	–	–	1	1103.0	7	7721.0
Larus argentatus						(2.0)	(11.4)	(8.6)	(19.9)
Black-tailed Gull	440.7	1	440.7	1	440.7	1	440.7	12	5288.4
Larus crassirostris	(n = 2)	(0.5)	(1.6)	(3.0)	(11.6)	(2.0)	(4.6)	(14.8)	(13.6)
Little Tern	57.0*	5	285.0	3	171.0	–	–	–	–
Sternula albifrons		(2.5)	(1.0)	(9.1)	(4.5)				
White-winged Tern	54.2*	–	–	–	–	1	54.2	1	54.2
Chlidonias leucopterus						(2.0)	(0.6)	(1.2)	(0.1)
Ancient Murrelet	201.2	18	3621.6	–	–	1	201.2	15	3018.0
Synthliboramphus antiquus	(n = 17)	(9.1)	(13.1)			(2.0)	(2.1)	(18.5)	(7.8)

Appendix. Continued.

Prey Item	Mean Body Mass of Prey (g)	Spring (March–Mid-June)		Summer (Mid-June–August)		Autumn (September–November)		Winter (December–February)	
		Frequency	Biomass	Frequency	Biomass	Frequency	Biomass	Frequency	Biomass
Japanese Murrelet	182.5	19	3467.5	–	–	–	–	1	182.5
Synthliboramphus wumizusume	(*n* = 13)	(9.6)	(12.5)					(1.2)	(0.5)
Oriental Turtle-dove	205.6	11	2261.6	1	205.6	3	616.8	7	1439.2
Streptopelia orientalis	(*n* = 5)	(5.6)	(8.2)	(3.0)	(5.4)	(5.9)	(6.4)	(8.6)	(3.7)
Rock Pigeon	354.5*	7	2481.5	–	–	2	709.0	4	1418.0
Columba livia		(3.6)	(9.0)			(3.9)	(7.3)	(4.9)	(3.7)
Oriental Cuckoo	108.3	1	108.3	–	–	–	–	–	–
Cuculus saturatus	(*n* = 6)	(0.5)	(0.4)						
Long-eared Owl	299.0*	1	299.0	–	–	1	299.0	–	–
Asio otus		(0.5)	(1.1)			(2.0)	(3.1)		
Oriental Scops-Owl	82.2	8	657.6	–	–	1	82.2	–	–
Otus sunia	(*n* = 12)	(4.1)	(2.4)			(2.0)	(0.8)		
Japanese Scops-Owl	195	1	195.0	–	–	–	–	–	–
Otus semitorques	(*n* = 1)	(0.5)	(0.7)						
Jungle Nightjar	85.6	2	171.2	–	–	–	–	–	–
Caprimulgus indicus	(*n* = 14)	(1.0)	(0.6)						
Pacific Swift	33.8*	1	33.8	–	–	–	–	–	–
Apus pacificus		(0.5)	(0.1)						
Black-capped Kingfisher	106.7	4	426.8	1	106.7	1	106.7	–	–
Halcyon pileata	(*n* = 7)	(2.0)	(1.5)	(3.0)	(2.8)	(2.0)	(1.1)		
Ruddy Kingfisher	77.5*	3	232.5	–	–	–	–	–	–
Halcyon coromanda		(1.5)	(0.8)						
Common Kingfisher	27.5	4	110.0	–	–	–	–	–	–
Alcedo atthis	(*n* = 34)	(2.0)	(0.4)						
Oriental Dollarbird	118.4	8	947.2	–	–	1	118.4	–	–
Eurystomus orientalis	(*n* = 2)	(4.1)	(3.4)			(2.0)	(1.2)		
Fairy Pitta	82	10	820.0	–	–	–	–	–	–
Pitta nympha	(*n* = 1)	(5.1)	(3.0)						
Sky Lark	31.8	–	–	–	–	–	–	1	31.8
Alauda arvensis	(*n* = 4)							(1.2)	(0.1)
Barn Swallow	13.9	1	13.9	–	–	–	–	–	–
Hirundo rustica	(*n* = 28)	(0.5)	(0.1)						
White Wagtail	19.3	–	–	1	19.3	1	19.3	–	–
Motacilla alba	(*n* = 16)			(3.0)	(0.5)	(2.0)	(0.2)		

Appendix. Continued.

Prey Item	Mean Body Mass of Prey (g)	Spring (March–Mid-June) Frequency	Spring (March–Mid-June) Biomass	Summer (Mid-June–August) Frequency	Summer (Mid-June–August) Biomass	Autumn (September–November) Frequency	Autumn (September–November) Biomass	Winter (December–February) Frequency	Winter (December–February) Biomass
Brown-eared Bulbul	63.8	1	63.8	–	–	–	–	–	–
Ixos amaurotis	(*n* = 26)	(0.5)	(0.2)						
Bull-headed Shrike	41.8	4	167.2	–	–	–	–	–	–
Lanius bucephalus	(*n* = 83)	(2.0)	(0.6)						
Brown Shrike	29.9	1	29.9	–	–	1	29.9	–	–
Lanius cristatus	(*n* = 10)	(0.5)	(0.1)			(2.0)	(0.3)		
Siberian Rubythroat	22.2	1	22.2	–	–	–	–	–	–
Luscinia calliope	(*n* = 20)	(0.5)	(0.1)						
Siberian Blue Robin	15	1	15.0	–	–	–	–	–	–
Luscinia cyane	(*n* = 37)	(0.5)	(0.1)						
Rufous-tailed Robin	15.9	1	15.9	–	–	–	–	–	–
Luscinia sibilans	(*n* = 22)	(0.5)	(0.1)						
Orange-flanked Bush-robin	12.5	1	12.5	–	–	1	12.5	–	–
Tarsiger cyanurus	(*n* = 90)	(0.5)	(0.0)			(2.0)	(0.1)		
Daurian Redstart	15.9	1	15.9	–	–	–	–	–	–
Phoenicurus auroreus	(*n* = 75)	(0.5)	(0.1)						
Eurasian Scaly Thrush	118	15	1770.0	–	–	5	590.0	–	–
Zoothera dauma	(*n* = 70)	(7.6)	(6.4)			(9.8)	(6.1)		
Pale Thrush	81	8	648.0	–	–	1	81.0	2	162.0
Turdus pallidus	(*n* = 40)	(4.1)	(2.3)			(2.0)	(0.8)	(2.5)	(0.4)
Brown-headed Thrush	60.3	1	60.3	–	–	–	–	–	–
Turdus chrysolaus	(*n* = 23)	(0.5)	(0.2)						
Eyebrowed Thrush	55.8	1	55.8	–	–	–	–	–	–
Turdus obscurus	(*n* = 21)	(0.5)	(0.2)						
Dusky Thrush	65.8	1	65.8	–	–	–	–	–	–
Turdus naumanni	(*n* = 25)	(0.5)	(0.2)						
Manchurian Bush-warbler	21.2	–	–	–	–	1	21.2	–	–
Cettia canturians	(*n* = 46)					(2.0)	(0.2)		
Oriental Reed-warbler	26	2	52.0	–	–	–	–	–	–
Acrocephalus orientalis	(*n* = 60)	(1.0)	(0.2)						
Narcissus Flycatcher	14.1	1	14.1	–	–	–	–	–	–
Ficedula narcissina	(*n* = 31)	(0.5)	(0.1)						
Mugimaki Flycatcher	11.2	1	11.2	–	–	–	–	–	–
Ficedula mugimaki	(*n* = 26)	(0.5)	(0.0)						

Appendix. Continued.

PREY ITEM	MEAN BODY MASS OF PREY (G)	SPRING (MARCH–MID-JUNE)		SUMMER (MID-JUNE–AUGUST)		AUTUMN (SEPTEMBER–NOVEMBER)		WINTER (DECEMBER–FEBRUARY)	
		FREQUENCY	BIOMASS	FREQUENCY	BIOMASS	FREQUENCY	BIOMASS	FREQUENCY	BIOMASS
Varied Tit	18.6	–	–	–	–	1	18.6	–	–
Parus varius	(n = 60)					(2.0)	(0.2)		
Japanese White-eye	13.2	1	13.2	2	26.4	–	–	–	–
Zosterops japonicus	(n = 50)	(0.5)	(0.0)	(6.1)	(0.7)				
Yellow-throated Bunting	17	1	17.0	–	–	1	17.0	–	–
Emberiza elegans	(n = 108)	(0.5)	(0.1)			(2.0)	(0.2)		
Yellow-billed Grosbeak	44.6	1	44.6	–	–	–	–	–	–
Eophona migratoria	(n = 18)	(0.5)	(0.2)						
Hawfinch	52.6	1	52.6	–	–	–	–	–	–
Coccothraustes coccothraustes	(n = 27)	(0.5)	(0.2)						
Black-naped Oriole	88.1	2	176.2	1	88.1	–	–	–	–
Oriolus chinensis	(n = 5)	(1.0)	(0.6)	(3.0)	(2.3)				
Eurasian Magpie	206.5	8	1652.0	3	619.5	1	206.5	–	–
Pica pica	(n = 23)	(4.1)	(6.0)	(9.1)	(16.2)	(2.0)	(2.1)		
Large-billed Crow	482.3*	1	482.3	–	–	–	–	1	482.3
Corvus macrorhynchos		(0.5)	(1.7)					(1.2)	(1.2)
INSECTS									
Globe Skimmer	0.3	–	–	–	–	1	0.3	–	–
Pantala flavescens	(n = 16)					(2.0)	(0.0)		
Lesser Emperors	0.6	–	–	6	3.6	–	–	–	–
Anax parthenope	(n = 6)			(18.2)	(0.1)				
TOTAL		197	27,669.0	33	3813.4	51	9678.3	81	38,745.3
		(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)