Free time in birds

How much and why?

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The proportion of maximal daily metabolizable energy (DMEmax) birds spend differs per bird according to Masman et al. (1989). The daily energy expenditure for small birds is closer to their DMEmax compared to big birds. In this study I will examine if this difference reflects in the free time of a bird, by gathering time budgets from various bird species and calculate the average amount of free time these birds have. Free time is generally defined as resting (but not sleeping or roosting) and perching (a low energy demanding form of hunting). In total 16 species have been examined. The results show that there is no correlation between the mass of a bird and the time it is free. A pattern is visible however, and removal of the 2 greatest outliers did make the correlation significant. The pattern disappeared when sexes were split, but sample sizes were reduced. A negative correlation was found between foraging time and free time, showing that birds that rest more spend less time foraging. Increasing the amount of data on time budgets and the protocol on how these are assessed is needed to either verify or abandon the hypothesis that mass and free time are connected.

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Introduction

In the avian kingdom, birds differ greatly in size. They can be as small as the Bee Hummingbird (*Mellisuga helenae*) with a wingspan of approximately 3.25 centimetres, whereas a Wandering Albatross (*Diomedea exulans*) can have a wingspan up to 3.5 metre in length.

Apart from the difference in size, there are many more aspects on which birds differ, e.g. habitat, nutrition, physiologically, longevity and reproduction. One particular thing birds differ on is energy budget. Masman *et al.* (1989) gathered the data of 30 different bird species concerning this subject. In his article he illustrated a discrepancy between the daily energy expenditure (DEE) of a bird and the maximum daily metabolizable energy (DME_{max}), depending on the mass of a bird. This means that the DEE of a bird of 25 g is 91% of his estimated DME_{max}, while a bird of 10 kg has a DEE of only 61% of the DME_{max}. In other words, smaller birds have a very tight energy budget, whereas bigger birds have ample room of compensation.

In the following sections I will (i) investigate if this difference in energy budget is reflected in the time budget of a bird, to find out if bigger sized birds actually have more spare time per day than the smaller ones, (ii) if foraging time is negatively correlated with free time and (iii) I will give a plausible explanation for the cause of free time in the discussion.

The free time a bird enjoys is not actually time where it does nothing. Instead it can be used to digest food, quiescence or other activities (Herbes 1981). In this study free time will be defined as low energy demanding activities which can be spend differently without major implications for the bird. Activities like resting (but not roosting or sleeping), perching (a low energy demanding type of hunting behaviour performed by many bird species (Rijnsdorp *et al.* 1981)) and sitting will be counted as so called "free" time of a bird.

Methods

For analyzing the average free time per day different bird species have, time budgets will be compared during the breeding season. Energetic demands are highest during this season (Markones *et al.* 2010), which means birds will have a DEE close to their DME_{max} and free time will be lowest.

The time a bird spends foraging, self-feeding and young-feeding will be presented as foraging, and the time spend resting, perching, standing or sitting will be presented as free time. All other activities are discarded during this study.

Not every study uses the same protocol to assess the time budget of a bird. Different activities are scored during different times of the day. Most articles present the time budget on the basis of daylight hours, daytime or bird activity time, without stating exactly how long the average daylight or bird activity was during the observations and neither if the bird was completely inactive during the night. In these occasions I assume that the time where no activities were scored lasted 8 hours which is the average time a bird sleeps or is roosting (Amlaner and Ball 1983).

Many studies distinguish between early, mid and late breeding or use other parameters. If different stages of the breeding time were used, mid breeding results are used in this report, which are similar to a few where there was no options to choose from. The mid breeding stage skips the first and sometimes the second week, depending on how long the nestlings stay in the nest, and disregards the very end of the nestling period when the chicks are nearly big enough to fledge.

Studies where time budget for males and females were scored separately are presented here separately, but also pooled. The reason for this is that not all studies distinguish between the time budget of male and female, so for proper comparison pooled data sets were created as well.

The description of the birds is derived from Wikipedia, unless more accurate descriptions were readily available. Since the statistics are done with free time in relation to mass, mass is either retrieved from the article used itself, or when not available there, acquired from other articles if proper values could be found.

The Willow Flycatcher (Empidonax traillii)

The willow flycatcher is a small grey bird living in the United States and Canada in summer, and migrates to Central America during the winter. The length of the bird is 15 cm and the wingspan 22 cm. The bird weighs 12.6 g on average (n = 10) (Ettinger and King 1980).

Soroka and Morrison (2005) observed the willow flycatcher in the Sierra Nevada in the summers of 2000 and 2001. 32 pairs were observed during 5 phases of the reproductive cycle, of which only the nestling phase is reported here (only 25 pairs were observed during this phase). During this phase the flycatcher spends 48.5 % of the day perching, which equals to 48.5 % * 16 * 60 = 466 minutes per day and (4.9 + 14.1 %) * 16 * 60 = 182 minutes per day foraging (16 % of the active day).

The Sand Martin (Riparia riparia)

The sand martin is a passerine bird that lives all over Europe and parts of Asia and North America and migrates to Africa, southern Asia or South America in the winter. The bird has a brown back and a white throat. It is a small bird, weighing roughly 12.6 g (Turner 1983) and is 12 cm long.

Turner (1983) did some work on the sand martin from May to August in 1977, 1978 and 1979, assessing the energy requirements and energy gain rates of parents raising different sized unmanipulated broods. 17 pairs of sand martins were observed during 100 1-hour periods. During this experiment she also assessed the time budgets of these birds. Different time budgets for the different sized broods were not described, so I assumed the time budget presented was an average of all brood sizes and birds. According to this budget a sand martin spends 11.9 % of a 24 hour day resting, or 11.9 % * 24 * 60 = 171 minutes. Foraging was not scored as a separate activity.

The Barn Swallow (Hirundo rustica)

The barn swallow is a passerine bird and the most widespread swallow in the world. The bird is found in Europe, Asia, Africa and both South and North America. The feathers of this bird are steel blue on top and white on the underparts. It is slightly bigger than the sand martin, mainly due to the elongated tail feathers, with a length of 17 - 19 cm for males and a wingspan of 32 - 34.5 cm. The female is similar in appearance but misses the elongated tail feathers. A barn swallow weighs 19 g (Turner 1983).

Turner also observed the barn swallow during the same period she observed the sand martin (see above) to compare the energetic of these 2 birds. She observed 11 pairs of barn swallows during 131 1-hour periods. The results showed that a barn swallow spends 15.8 % of the 24 hour day in rest, which is 15.8 % * 24 * 60 = 228 minutes. Foraging or feeding activities were not scored for the barn swallow.

The Phainopepla (Phainopepla nitens)

The Phainopepla is a silky-flycatcher found mostly in California and Mexico. The male has black feathers, whereas the female is plain grey. The wings have a white patch which can be seen during flight. It is 16 - 20 cm long and weighs roughly 24 g (n = 33) (Walsberg 1978).

In 1974 and 1976 Walsberg worked on the energetic of the Phainopepla (Walsberg 1978). Observations were done from the 15th of June till the 4th of July in the coastal woodlands of California. He distinguished between sex and brood size, to test the influence of both, but in this study brood size differences will be discarded. Brood size was either 2 or 3 with an average of 2.46. 7 types of behaviour were distinguished, namely: (1) flight; (2) perching; (3) transit, including all locomotion when social behaviour or flycatching were not involved; (4) foraging at a fruiting shrub; (5) flycatching, including only the time actually spend in flight; (6) nest attentiveness, the time spend at the nest; and (7) social activity, including aggression and territorial displays. The time spend perching will be regarded as free time. Foraging and flycatching will be both be regarded as foraging. Only daytime observations were done, lasting 14.56 hours on average. I assumed the Phainopepla had no free time during the remaining hours. For each male the time spend perching was calculated separately, due to the differences in length of active day. The same calculation is used for foraging, except here the time spend foraging and flycatching is added. The calculation looks as follows: $\Sigma(P * M_x) / T$

Where P is the percentage time perching, M is length of active day for male x, and T is total amount of males, which is 8. The result times 0.60 is the amount of minutes a male spends perching per day.

Using this calculation, it shows that a male phainopepla spends 530 minutes per day resting, a female 488 and the species on average 509. The time spend foraging is 65 and 67 minutes for males and females respectively and 66 minutes for the species.

The Semipalmated Sandpiper (Calidris pusilla)

The sandpiper is a small shorebird that breeds in Canada and Alaska, with a length of 12.7 cm. After the breeding season they migrate to the southern parts of the United States and the shores of South America to spend the winter there. The feathers are dark-grey and brown on top, and white underneath. Sometimes they can be seen in Europe as well. The males weigh 25.4 g (n = 164) and the females 28.7 g (n = 190) (Ashkenazie and Safriel 1979).

In 1973 Ashkenazie and Safriel observed the sandpiper to assess the time energy budget. During the observations they distinguished different stages of reproduction, such as territorial defence, laying, incubation and young attending. For better comparison with the other articles used in this study, I will restrict myself to the young attending stage only. 10 types of activities were scored during the observations: (1) sleeping; (2) incubating; (3) brooding; (4) feeding, (5) standing alertly & calling; (6) walking, running and ground display; (7) standing; (8) preening & washing; (9) normal flight and (10) intense flight. Only the activity marked as standing will be used to assess free time in the sandpiper and time spend feeding will be used as foraging. For the male there are 2 stages of young attendance. The average of standing in both stages will be taken to assess his free time. During the nestling rearing phase 2 males and 2 females were observed, with an average observation period per individual of just over 15 hours. True values are not shown in the articles, but displayed in a graph, so values presented here are estimates. The male is estimated to spend 6 and 33 % standing in the young attending stages and 30 and 50 % feeding. This means a male has 19.5 % * 24 * 60 = 281 minutes of free time and is feeding 40 % * 24 * 60 = 576 minutes in a full day. The percentages for the female are estimated as 44% feeding and 10% standing, which equals to 634 and 144 minutes of feeding and resting respectively. For sexes taken together the values are 212 minutes rest and 605 minutes of feeding.

The Abert's Towhee (Pipilo aberti)

The brown feathered abert's towhee lives in North America. They are 24 cm long with a wingspan of 33 cm and weigh 46.8 g (n = 13) (Finch 1984).

In 1980 this bird was observed by Finch in Arizona. 4 different types of activity were scored to assess its time and energy budget: perching, ground foraging, flying and nest attendance. Date from the nestling phase is presented in table 6. 3 males and 15 females were observed for 720 and 3700 minutes respectively to gather the data. During the nestling phase the activity of the abert's towhee is estimated to be 15 hours per day according to Finch. Male abert's towhees spend 43.1 % perching and 49.7 % foraging during this time, equaling to 43.1 % * 15 * 60 = 388 minutes perching and 49.7 % * 15 * 60 = 447 minutes foraging. Female percentages are 10.4 and 38.6, equaling to 94 minutes perching and 397 minutes foraging per day.

The Northern Mockingbird (Mimus polyglottos)

The mockingbird is a small bird that only lives in the southern parts of North America. It is a grey bird with dark wings and weighs 54.8 g (n = 5) (Biedenweg 1982). The bird is roughly 25 cm long with a wingspan of 36 cm.

To assess the time and energy budgets of a mockingbird, Biedenweg observed 5 mockingbirds near the University of California in 1978. 3 types of activities were scored: perching, flying and bipedal locomotion. Several stages of reproduction were distinguished, only the date during the nestling phase is reported here. The male time budget is gathered from 1100 minutes of data observing 3 males, the female time budget from 1170 minutes observing 3 as well. Male mockingbirds spend 91.7 % or (91.7 % * 16 * 60) 880 minutes of the active day perching, whereas females spend 90.9 % or 873 minutes. The average for the species is 877. Foraging activity was not scored.

The Starling (Sturnus vulgaris)

The starling is a passerine bird resident in the temperate parts of Europe and western Asia; it has also been introduced into other parts of the world. Commonly it has black plumage with white dots. The bird is 19 - 22 cm long with a wingspan of 37 - 42 cm. The male starling weighs 75g and the female 71 g (Meijer et al. 1994).

In a long term study performed by Lundberg (1985), time budgets for the starling were created by observing 2 starling populations. One population was observed at Andøya Norway,

the second lived in Umeå Sweden. The starlings at Andøya were observed 156 times (number of total individuals is presumably lower) with a total observation time of 59 hours. The starlings in Umeå were observed 55 times (number of total individuals is presumably lower) with a total observation time of 19 hours. The observations took place from 1981 till 1984. Time budgets were created for almost every month of the year. Here I will use the time budget of June, the period the nestlings are raised. Lundberg does not score nighttime activities in his article, so I will assume the time budget is the budget during 16 hours of daytime. 8 different types of behaviour were scored, but his results only distinguish between male and female on the 3 major types of behaviours, namely: resting, singing and foraging. Therefore only that data will be used here. Using the formula percentage time spend * 16 * 60 shows that the Andøya rests 150 minutes per day (192 and 108 minutes for males and females respectively) and the Umeå starling rests 160 minutes per day (148 and 170 minutes for males and females respectively). Time spend foraging is 683 minutes for the Andøya starling (male 621, female 744) and 744 for the Umeå starling (male 730, female 757).

The Common Kestrel (Falco tinnunculus)

The common kestrel is a bird of prey living mainly in Europe, Asia and Africa, but has also been spotted in North America and other parts of the world. The feathers of the kestrel are chestnut brown with black spots. The bird is a relatively small bird of prey. It is 32 - 39 cm long with a wingspan of 65 - 82 cm. Males weigh 200 g on average (n = 447) and females 248 g (n = 496) (Dijkstra *et al.* 1988).

Masman *et al.* (1988) assessed the time budget of the kestrel living in the Netherlands. In the study Masman *et al.* observed 76 different kestrels from 1977 till 1984, of which 760 days were used for observations. During the breeding period 39 males and 16 females were observed with an average observation time per kestrel of 15 hours (estimated from the total observation time divided by the total number of observations). Because of the high amount of data, time budgets were made for both each month of the year and phase of the reproductive cycle. Here I will use the phase of the reproductive cycle where nestlings were more than 10 days of age, for better comparison with the other articles used in this study. 7 different behavioural states were scored: (1) flight-hunting; (2) soaring; (3) flying; (4) perching; (5) sitting; (6) incubation and brooding; (7) night rest. Both sitting and perching behaviour is counted as free time and flight-hunting as foraging time. Both males and females have free time half of the day (male 20.8 sitting + 29.2 perching = 50 %; female 14.6 sitting + 35.4 perching = 50 %), which is 720 minutes. Foraging time is 13.5 % for the male, which equals to 13.5 % * 24 * 60 = 194 minutes, and 8.3 % for the female, equaling to 120 minutes.

The Pied Avocet (Recurvirostra avosetta)

The pied avocet is a black and white coloured wader, breeding in Europe and central Asia during the summer and migrating to Africa and southern Asia during the winter. It is 42 - 45 cm in length with a long bill (7.5 - 8.5 cm). The wingspan is 77 - 80 cm and the bird weighs 325 g (Piersma *et al.* 2003).

Hötker (1991) examined the avocet in a wide variety of placed, ranging from Denmark to Senegal to follow the bird through the entire annual cycle. Here only the observations done at

Fahretofter Westerkoog will be displayed, during which the breeding took place. The data displayed here is the average of the 7 observations from the 2nd of May till the second of July. The average percentage of time resting during this period is 34.57 % from 12 hour period observations. The percentage time foraging is 17.57 %. Thus, pied avocets rest 34.57 % * 12 * 60 = 249 minutes and forage 17.57 % * 12 * 60 = 127 minutes of the active day. The difference between sexes was not scored.

The Eurasian Oystercatcher (Haematopus ostralegus)

As the name implies, the Eurasian oystercatcher is an oystercatcher that lives in Europe and Asia. The wader is 40-45 cm long with a wingspan of 80-85 cm. The bird has black and white plumage with a long orange bill (8 - 9 cm). Mean male mass is 500 g (n = 5), mean female mass is 545 g (n = 2) (Kersten 1996).

Kersten (1996) described the time and energy budget of the ovstercatchers with different quality territories. The difference in territory quality was due to the travelling time from nest to feeding area. 'Resident' ovstercatcher have these areas lying next to each other, whereas 'leapfrog' ovstercatcher have to travel a distance of 200 - 500 m to reach the feeding area. The observations were done during the breeding season (April till August) from 1985 till 1988 on the island of Schiermonnikoog (the Netherlands). 11 male and 10 female resident oystercatchers were observed. 31 male and 31 female leapfrog oystercatchers were observed. The breeding season was divided into three stages, pre-laying, incubation and chick-rearing. Here the chick-rearing stage will be used. The time budgets observed by Kersten are those of low water periods only, because the oystercatcher cannot find food during high water periods. Activity was classified into 6 categories: (1) foraging, (2) resting; (3) other; (4) aggression; (5) walking; (6) flying. Resident ovstercatchers were inactive during 36.6 % of the low tide period, which equals to 36.6 % * 6.93 (low tide time) * 60 = 152 minutes (males 38.3 % or 159 minutes; females 34.9 % or 145 minutes). Whereas leapfrog oystercatchers spend 42.85 % of the low tide inactive or 42.85 % * 5.66 * 60 = 146 minutes (males 43.4 % or 147 minutes; females 42.3 % or 144 minutes). Foraging time for the resident oystercatchers are 34.6 % for the male (144 minutes), 30.9 % for the female (128 minutes), whereas foraging time for leapfrog oystercatchers is 35.9 and 37.2 % for males and females respectively (122 minutes and 126 minutes). Foraging time for the sexes combined is 32.7 % (136 minutes) time spend foraging for resident oystercatchers and 36.6 % (124 minutes) for leapfrog oystercatchers.

The American Coot (Fulica americana)

The American coot lives mainly in North America and has a dark grey plumage. Its size is 40 cm in length with a wingspan of 64 cm. They weigh roughly 650 g.

Ryan and Dinsmore (1980) observed the coot in Iowa in 1976 and 1977. 10 categories of activities were presented in the article, of which the amount of loafing, feeding and feeding of young is presented here (feeding and feeding of young are pooled as foraging). 3 different age classes were recognized and distinguished, however, here the weighted means are used. Data is obtained from 30 males and 25 females from a total of 467 hours of observation. Observations were done from 6:00 in the morning till 20:00 in the evening. The results show

that male american coots forage 57.88 % * 14 * 60 = 486 minutes per day and female coots forage 577 minutes per day (532 minutes on average). Free time per day was considerably lower, namely 10 minutes for males, 6 for females and 7 minutes for the species on average.

The Peregrine Falcon (Falco peregrinus anatum)

The peregrine falcon is a bird of prey that is spread all over the world. It has a blue-grey back with white underparts and a black head. Its size varies from 34 - 58 cm with a wingspan ranging from 80 - 120 cm. The male of the anatum subspecies weighs 500 - 570 g, whereas the considerable larger female weighs 900 - 960 g.

In 1995, 1996 and 1997 Palmer *et al.* observed the falcon along the Tanana River in Alaska to find different factors influencing the time budgets of the falcon. A number of stages were distinguished: incubation, early nestling-rearing, mid nestling-rearing, late nestling-rearing and post fledging. Here the date of only mid nestling-rearing is used, to match the relative age of the nestlings in the other articles. During this stage 25 pairs of falcons were observed over the 3 years. The following behaviours were scored: (1) incubating/brooding; (2) perching; (3) self feeding; (4) young feeding; (5) flying. Perching is used to calculate free time, and the sum of self feeding is used as indication of foraging time. Time budgets were created on mostly daytime observations. This shows that male falcons spend 36.6 % (36.6 % * 16 * 60) or 351 minutes perching per day and 0,41 % ((0.28 % + 0.13 %) * 16 * 60) 4 minutes feeding., females 515 perching and 9 minutes feeding, and the average of the species is 433 minutes perching and 6 minutes feeding.

The Kelp Gull (Larus dominicanus)

The kelp gull is resident to the southern hemisphere. It is white feathered with black wings. The average length and wingspan are 60 and 135 cm respectively and the bird weighs 905.3 g (n unknown) (Gray and Erasmus 1989).

The kelp gull was subject of observation during the warmer periods of Antarctica from 1978 till 1980 (Maxson and Bernstein 1984). Several stages of reproduction were distinguished; the mid nestling stage is used here. 13 different activities of the gull were scored, of which inactivity and foraging is presented here. 144 birds were observed to gather the data, which is acquired from a graph so numbers might not be 100% accurate. Male gulls were inactive 55 % of the day, or 792 minutes, female gulls were inactive 25 % or 360 minutes (average inactive time 40 % * 24 * 60 = 576 minutes). Males spend 20 % of the time foraging (288 minutes), females 3 % (43 minutes) and the species on average 11.5 % (166 minutes).

The Osprey (Pandion haliaetus)

The osprey is a large fish-eating bird of prey. It is 50 - 66 cm in length with a wingspan of 127 - 180 cm. The males weigh roughly 1428 g (Green and Ydenberg 1994). Females weigh 30% more than males, so female mass is approximately 1856 g. The upper parts of the bird are brown, with a white breast and white under parts. The head is white with a dark mask across the eyes. The bird can be found worldwide in temperate and tropical regions, mostly near water.

Green and Ydenberg (1994) observed 11 male ospreys in British Columbia to assess their DEE under different brood size conditions. Even though brood size manipulations were done during this experiment, the manipulations did not affect the time budget of the males. However, only male time budgets were made, so no female data is available. The time budgets were assessed at different times of the brood age. I will average the data from week 3 till 6 to stay in line with the observations from the other articles. During this stage of the reproduction, the male osprey is perching 83 % of the time, or 83 % * 16 * 60 = 797 minutes. 9 % of the active day the osprey is flight-hunting, which equals 86 minutes.

The Golden Eagle (Aquila chrysaetos)

The golden eagle is large bird of prey living in the Northern Hemisphere. This eagle is dark brown with lighter golden-brown plumage on the head and neck. The length of the bird is 1 m and their wingspan is 2 m on average. Males weigh roughly 3477 g (n = 31), and the female mass is 4913 (n = 18) (Bedrosian *et al.* 2008).

From 1977 till 1979 Collopy and Edwards (1989) observed 4 eagle pairs in southwestern Idaho during the breeding season. Daylight time budgets were created separately for males and females, and converted here to 24 hour time budgets. 330 hours of male observations were used to assess the time budget, and 413 hours for the female. The activities scored for the eagle fall into 2 major categories: perching and flying. Perching activities were subdivided into 4 smaller categories. From the perching activities, only self maintenance is not used to calculate the free time. This means a male eagle spends 1.3 % +74 % +1.2 % = 76.5 % perching, or 76.5 % * 16 * 60 = 734 minutes, and females 83.9 % or 805 minutes. The average time spend perching for the golden eagle is 80.2 % of the active day, or 769 minutes.

Results

Table 2 (below) shows the date of all 16 species together, in table 1 the sexes are split for the available species. For proper interspecies comparison, data from both starling populations have been pooled, as well as the data from resident and leapfrog oystercatchers.



Figure 1: Free time plotted against log-mass. 1. Willow Flycatcher; 2. Sand Martin; 3. Barn Swallow; 4. Phainopepla; 5. Semipalmated Sandpiper; 6. Abert's Towhee; 7. Northern Mockingbird; 8. Starling; 9. Common Kestrel; 10. Pied Avocet;11. Eurasian Oystercatcher; 12. American Coot; 13. Peregrine Falcon; 14. Kelp Gull; 15. Osprey; 16. Golden Eagle

Free time

Analysis showed free time does not scale with the mass of a bird (p = 0.26, N = 16). Removal of the 2 biggest outliers did give a significant result however (p = 0.04, N = 14). The 2 greatest outliers were the mockingbird (the only study done near the vicinity of human beings) and the american coot (with an unusual high amount of time spend feeding). In figure 1 the free time of a species is plotted against the log-mass. Foraging time was not correlated with mass either. The sample size for this analysis was reduced, due to less data on time budget of foraging time (p = 0.30, N = 12).



Figure 2: Free time plotted against forage time. 1. Peregrine Falcon; 2. Phainopepla; 3. Osprey; 4. Eurasian Oystercatcher; 5. Common Kestrel; 6. Kelp Gull; 7. Willow Flycatcher; 8. Pied Avocet; 9. Abert's Towhee; 10. American Coot; 11. Semipalmated Sandpiper; 12. Common Starling

Next however, the correlation between foraging time and free time was tested, what did result in a significant result (p = 0.02, N = 12). A negative correlation was found, showing that birds that spend more time resting need less time foraging. Results are shown in figure 2.

Differences in sex

Some of the articles provided data for both sexes instead of the species as a whole. Significance was tested for males and females separately for these time budgets. P-values for males and females were 0.54 and 0.82 respectively, however sample sizes were reduced (N = 12 for males, N = 11) for females). Figure 2 shows the data for which sexes were split. Forage time was not correlated with bird mass either (p = 0.30 for)males, p = 0.46 for females). When testing the correlation between free time and forage time no significant result was found in either of the sexes.



Figure 3: Free time plotted against log-mass split for sexes. Circles are male, dots are females. 1. Phainopepla; 2. Sandpiper; 3. Abert's Towhee; 4. Northern Mockingbird; 5. Starling; 6. Common Kestrel; 7. Eurasian Oystercatcher; 8. American Coot; 9. Peregrine Falcon; 10. Kelp Gull; 11. Osprey; 12. Golden Eagle

Species	Time spend resting by male	Time spend resting by female	Time spend foraging by male	Time spend foraging by female
Phainopepla	530	488	65	67
Sandpiper	281	144	576	634
Abert's towhee	388	94	447	347
Mockingbird	880	873	n/a	n/a
Starling	170	139	676	751
Kestrel	720	720	194	120
Oystercatcher	153	145	133	127
Coot	10	6	486	577
Falcon	351	4	515	9
Gull	792	360	288	43
Osprey	797	n/a	86	n/a
Eagle	734	805	n/a	n/a

Table 1: Resting and foraging time for sexes split.

Species	Scientific name	Order	Mass (g)	Foraging time (min)	Free time (min)	Number of birds observed *
Willow Flycatcher	Empidonax traillii	Passeriformes	12.6	182	466	50 (25)
Sand Martin	Riparia riparia	Passeriformes	12.6	n/a	171	34 (17)
Barn Swallow	Hirundo rustica	Passeriformes	19	n/a	228	22 (11)
Phainopepla	Phainopepla nitens	Passeriformes	24	66	509	16 (8)
Semipalmated Sandpiper	Calidris pusilla	Charadriiformes	26.1	605	212	4 (2)
Abert's Towhee	Pipilo aberti	Passeriformes	46.8	397	241	18 (3)
Northern Mockingbird	Mimus polyglottos	Passeriformes	54.8	n/a	877	6 (3)
Starling	Stumus vulgaris	Passeriformes	73	714	155	211 **
Common Kestrel	Falco tinnunculus	Falconiformes	224	157	720	55 (39)
Pied Avocet	Recurvirostra avosetta	Charadriiformes	325	249	127	7
Eurasian Oystercatcher	Haematopus ostralegus	Charadriiformes	523	130	149	83 (42)
American Coot	Fulica americana	Gruiformes	650	532	7	55 (30)
Peregrine Falcon	Falco peregrinus anatum	Falconiformes	733	6	433	50 (25)
Kelp Gull	Larus dominicanus	Charadriiformes	905	166	576	144
Osprey	Pandion haliaetus	Accipitriformes	1642	86	797	(11)
Golden Eagle	Aquila chrysaetos	Accipitriformes	4195	n/a	769	8 (4)

Table 2: All data gathered. * Number of observed males in brackets; ** Did not distinguish between birds, actual number may be lower.

Discussion

Every bird has a limited amount of energy it can use every day, limited by its reserves it can build up (McNamara *et al.* 1987). Thus, proper allocation of energy is crucial to the survival of the bird. However, Wilson (1975) raised the problem that animals in nature devote much of their time doing nothing productive. To solve this problem, he proposed 2 explanatory hypotheses: The principle of allocation and the principle of stringency. The former one explains the non-productive time as the priority of food intake over other requirements, so time spend doing nothing might actually be used for digestion. The latter one states that time budgets have evolved to see animals through periods of food shortage, where a bird needs to perform at the maximum, whereas during times where food is abundant, the bird has to forage less and has free time.

In practice, a combination of both hypotheses is most likely in effect. A bird which has free time during periods of high food availability will start using this time to digest the food, whereas if a bird would prioritizes food intake over other requirements, it will appear to spend time doing nothing. Further investigation on how birds actually spend this free time is needed to find out how both hypotheses interact.

Even though no significant result was found using the 16 species for analysis, many birds do seem to follow a general pattern (figure 1). More species and more detailed time budgets are required to prove or disprove the correlation between mass and free time in bird. If however the correlation is true, what could explain this phenomenon? This might be the result of (1) the positive correlation between body size and lifespan (Speakman 2005) and (2) the trade-off between current and future reproductive success (Nilsson and Svensson 1996). Since bigger birds live longer they can produce more clutches during a lifetime than smaller birds. Therefore they can choose to invest less in a current brood to enhance the success of future clutches and hereby enhancing overall reproductive success. The reduction of current parental effort in order to increase lifetime reproductive success can therefore explain the increased free time bigger birds enjoy.

As Herbes (1981) suggested, a more efficient forager needs to spend less time foraging to achieve the same amount of food, thus spends less time foraging. Even though foraging time and free time depend on many different factors (e.g. diet, habitat, predation, mortality), the negative correlation between foraging and free time was found here. Further analyses on all factors influencing foraging time are needed to clarify the connection with free time. The correlation was lost when sexes were split. However, in many species the time budgets of males and females differ greatly, and in some they do not, e.g. a male raptor supplies the food and nesting material, and the female is the one taking care of the young (Green and Ydenberg 1994).

The relationship between body size and free time might not be true for all species. As the results show the american coot and the northern mockingbird both do not follow this pattern, however this might be due to other factors (defining feeding and interference of human beings). Apart from the sample size, a standardized protocol for assessing time budgets will further increase the power of interspecies studies. In the articles I presented here there is a huge amount of variety in how the time budgets were created. The number of activities scaled from 3 to 28 different categories and it was not always clear under what categories certain activities fell, e.g. foraging was not always scored, but neither was stated if it happened during flying, perching or other activities.

Proper documentation of observation time is required for trustworthy time budgets as well. Many time budgets that are reviewed here were assessed during daytime or daylight hours, without stating the mean start and end time of the daylight. Information on night-time activity was not always supplied either.

Even though the data presented in the articles is gathered using different protocols, the pattern observed in the analysis appears to be true for some species. Before any conclusions can be drawn however, the time budgets of additional species need to become available and the protocol for activity scoring needs to be enhanced.

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