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att åldersfördelningen som vi har observerat är typisk för en normal population.

En nyckelfråga är hur man åldersbestämmer en fågel korrekt. Om detta inte kan göras ordentligt kan man inte jämföra olika populationer eller bestämma andelen av en ålderskategori eller dess variation. Många av de fjorton fåglarna som vi åldersbestämde använde samma revir året efter (en märkt fågel sågs i samma revir) och en märkt bounge återvände året efter och häckade (denna fågel är inte inkluderad bland de fjorton).

Svensson (1992) uppger för åldersbestämning under våren: "many second calender year birds can be recognised.....". Vikten av att förstå ruggning och slitage vid åldersbestämning har exploderat under det sista decenniet. De citerade studierna utfördes för nästan två decennier sedan.

En sak som är missledande är att Sorjonens (1977) och våra egna siffror har samlats in över tre säsonger. Detta anger inte situationen för varje år. Hos Sorjonens population måste det ha funnits fåglar som återvände året efter och då måste andelen gamla fåglar ha varit ännu större.

Näktergalen har under de sista decennierna spridit sig i Finland. Studier som gjorts kan ha rört onormala eller ostabila populationer. Numerären var omkring 200 par under tidigt 50-tal (Merikallio (1958) och ökade till runt 8000 par i början på 80-talet (Hildén & Koskimies (1984). Den finska population måste ha betett sig på ett sätt som inte kan betraktas som normalt när den expanderade och ökade.

Sydnäktergalen borde vara en bra indikator också för när näktergalen börjar häcka. Efter att ha lusläst Grüll (1981) är vår åsikt att uppgifterna i Glutz & Bauer (1988) verkar pålitliga. Grüll (1981) ger siffror för varje år och detta är mycket viktigt. Siffror, framräknade av oss, för varje säsong ger för de häckande hannarna: 55% 3K+ och 45% 2K per säsong i genomsnitt. Slutsatsen måste bli att sydnäktergalen börjar häcka som 2K. Om Sorjonens åldersbestämning var riktig måste hans population ha varit speciell och inte representativ för näktergalen.

Inget nytt har visat sig i litteraturen och vi drar då slutsatsen att näktergalen mest sannolikt börjar häcka som 2K. Uppgifterna i speciellt Cramp (1988) om näktergalen borde enligt vår åsikt revideras.

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Bird kills on roads: is this mortality factor seriously underestimated?

SÖREN SVENSSON

Introduction

With a new approach of sampling birds killed by road traffic, I estimate the total annual kill in Sweden to be almost ten million birds. This is almost an order of magnitude higher than a previous estimate and may indicate that the road toll of certain wildlife populations may have been seriously underestimated.

Man is the cause of many kinds of changes of the bird fauna. Farming is one of the most important factors since it transforms the landscape fundamentally, for better or worse, depending on the species. But modern farming is generally detrimental because it so intensively exploit major parts of the landscape. Forestry also affects the bird fauna over large areas but less fundamentally than farming. The spread of toxic chemicals, including pesticides, may affect certain species directly but the main effect is elimination of invertebrates and seeds as food for farmland birds. The effects of acidifying compounds and nutrients are also most often not direct but operate via habitat modifications, but their roles are unclear. Nutrients have in fact had considerable positive effects on bird abundance in both freshwater and marine environments.

But man also kills birds directly, deliberately by hunting or unintentionally when birds collide with windows or power lines or are taken by domestic cats. Another such factor causing mortality is road traffic. One might think that these factors are marginal compared with the habitat transformations. So it is, but they may still be important locally. Cats, for example, have been estimated to kill about ten million birds annually in Sweden (Svensson 1996). Although this is only about 3% of the total mortality, it may heavily affect local populations in towns and villages where there are many cats. And these factors may together, even if each of them has only a marginal effect, substantially reduce total population size.

Based on data collected by counting dead birds along a number of sample roads in different parts of the country, Göransson et al. (1978) estimated the total road kill to be about 500.000 and not more than one million birds. Their data were collected during

a few years time around 1975. However, most of the roads were patrolled by car only twice a day by people driving between home and work-place. These data could not be used for the estimation of total numbers. It was mainly a 16.5 km road between Revingeby and Lund in Scania and partly a 10.5 km road between Ed and Hökdalen in Dalsland (patrolled by bicycle) that produced good data. Particularly the former road was studied in great detail from April 1973 through October 1976.

In this study I have taken another approach. I have recorded every bird that has been killed in collisions with my own car during a period of nine years. Although this is a small, and possibly biased, sample, this approach ought to give some and perhaps better information about the total road kill if extrapolated to the total traffic volume.

Collection of data

From 22 October 1989 through 21 October 1998, i.e. a period of nine years, I recorded all cases of collisions between a bird and my own car. When I observed or suspected a collision, I stopped to look for the bird in order to identify the species. It was not always possible to find the bird, so in some cases I could only determine roughly what kind of bird it was. But it was always easy to tell if it was a small passerine or something else. All records are summarised in Table 1, where I also give some comments about the circumstances. I did not record my exact speed, the precise kind of road, or all details about the surroundings. However, the information that I wrote down, or recall, is included.

During the nine years I drove a total of 288,000 km, i.e. an average of 32,000 km per year, about the same every year. A large part of the drives was between my home in Torna Hällestad and my work-place in Lund (almost 10,000 km a year). Most of the rest refers to drives between Lund and Ammarnäs and Abisko in Lapland and other field work sites all over the country (roughly 15,000 km). Lesser parts were various shorter drives, private as well as to field work localities.

Results

The number of recorded birds is too small to analyse them in relation to different categories of circumstances (road type, driving speed, part of the country, season, time of day, etc.). Table 1 shows that the total number of birds killed was 29. This means that the number of records was 3.22 per year or 1.0069, or almost exactly one bird per 10,000 km.

The total number of kilometres driven by cars in Sweden can be calculated by multiplying the number of cars by the mean number of kilometres driven by the average car. The number of cars in Sweden was in 1995 3,631,000 passenger cars, 308,000 lorries, and 15,000 busses (Statistiska centralbyrån 1997). Passenger cars are driven on average 18,000 km and lorries 62,000 km (Gun-Britt Ljungdahl, statistikenheten, AB Svensk Bilprovning). I have no figure for busses, but include them among lorries. The figure for lorries refers to "heavy" lorries (>5 tons); it is possible that lighter lorries are driven less, but this affect the caluclation only marginally and towards a more conservative estimate of the number of kills. Thus the total number of kilometres travelled by road vehicles in 1995 was 85,384,000,000 km. With one bird killed per 10,000 km this means that a total of about 8.5 million birds are killed by road traffic every year in Sweden. An average passenger car driver will kill about 1.8 birds per year. However, the median distances driven were lower than the average distances, for passenger cars 14,000 km and for lorries 31,000 km, so the majority of drivers would experience fewer kills and a minority many more.

It would be possible to estimate the number of kills caused by different makes of cars by multiplying the average mileage given by Svensk Bilprovning AB (1998) with the number of registered cars of each make (Statistisk årsbok). I have not done this but the figures show that some of the most common cars, such as Volvo and SAAB, also show the highest mileages, much higher than the average car, and hence are responsible for most kills. I do not think that the risk of killing a bird differs much between different makes of cars, but if this should be the case I just mention that the cars I used during the nine study years was Ford Granada (half the period) and Volvo 700.

Discussion

The key question is of course whether I have been an average driver, particularly in terms of how my driving has sampled the Swedish roads properly. I know nothing about this and hence can do nothing more than apply the figure I have obtained. However, I think that there is little risk of overestimating the kill because of two reasons. First, it is almost certain that I have missed some birds. In many of the cases the bird that actually was recorded, flew very low over the road, below the front of the car. Many such cases may have been missed. For example, the

Table 1. Recorded cases of collision between bird and car during nine years.
Registrerade kollissioner mellan bil och fåglar under nio år.

Year	Date	Species	Year	Road	Surrounding Vegetation	Circumstances
1989	22 Oct.	Pheasant *Fasan*	Farhult, Scania	Paved Broad	Farmland	walked out from roadside vegetation, high speed
1989	winter	small passerine *liten tätting*	Dalby, Scania	Town Street	Gardens	flew up from roadside, low speed
1990	10 June	Fieldfare *Björktrast*	Olden, Jämtland	Narrow Dirt	Forest	flew over road, low speed
1990	23 June	Willow Tit *Talltita*	Djupfors, Västerbotten	Paved Broad	Forest	flew over road, high speed
1990	18 July	Tree Sparrow *Pilfink*	Dalby, Scania	Town Street	Gardens	flew up from roadside, low speed
1991	28 April	House Sparrow *Gråsparv*	Dalby, Scania	Town Street	Gardens	flew up from roadside, low speed
1991	15 Aug.	Whinchat *Buskskvätta*	Torna Hällestad, Scania	Paved Broad	Farmland	passed over road, low speed
1992	1 June	Fieldfare *Björktrast*	Mellan Sorsle och Ammarnäs, Västerbotten	Paved Broad	Forest	flew over road, high speed
1992	16 June	Willow Warbler *Lövsångare*	Mellan Abisko och Ammarnäs	Paved Broad	Probably forest	stuck in radiator grill of car, probably high speed
1992	29 June	Willow Warbler *Lövsångare*	Ammarnäs, Västerbotten	Paved Narrow	Forest	Low speed
1992	4 July	Bullfinch *Domherre*	Mellan Ammarnäs och Sorsele	Paved Broad	Forest	low speed
1992	4 Aug.	small passerine *liten tätting*	Mellan Resmo och Ottenby, Öland	Paved Broad	Farmland with bushes	flew up from roadside, high speed
1992	10 Oct.	small passerine *liten tätting*	Mellan Sjöbo och Vitaby, Skåne	Paved Broad	Farmland	flew up from roadside, high speed
1993	5 June	Bluethroat *Blåhake*	Kiruna, Norrbotten	Town Street	Open grassland	flew out from roadside bushes, low speed
1993	19 July	Tree Sparrow *Pilfink*	Dalby, Skåne	Paved Broad	Farmland	high speed
1993	15 Aug.	Bluethroat *Blåhake*	Ammarnäs, Västerbotten	Narrow Dirt	Mire with bushes	flew out from roadside bushes, low speed
1993	9 Oct.	Greenfinch *Grönfink*	Mjällby, Blekinge	Paved Broad	Forest	No record
1994	14 May	Greenfinch *Grönfink*	Björnstorp, Skåne	Narrow Dirt	Forest	flew out from hedge, low speed*
1994	26 May	Thrush Nightingale *Näktergal*	Tvedöra, Skåne	Narrow Dirt	Famland with bushes	sat on road in rain before dawn, low speed**
1994	8 Aug.	small passerine *liten tätting*	Mellan Färjestaden och Ottenby, Öland	Paved Broad	Farmland with bushes	Flew up from roadside, high speed
1994	8 Oct.	Greenfinch? *Grönfink?*	Tollarp, Skåne	Paved Broad	?	?
1995	25 May	Willow Warbler *Lövsångare*	Torna Hällestad, Skåne	Broad Dirt	Forest	Flew over road after sunset, low speed
1995	4 July	Great Tit *Talgoxe*	Vansbro, Dalarna	Paved Broad	Forest	Flew over road, high speed
1995	4 July	Pied Flycatcher *Svv. flugsn.*	Grythyttan, Västmanland	Paved Broad	Forest	Flew over road, high speed
1995	8 Sept.	Tree Sparrow *Pilfink*	Dalby, Skåne	Town Street	Gardens	Flew up from roadside, low speed
1996	8 July	Willow Warbler *Lövsångare*	Hoting, Ångermanland	Paved Broad	Forest	flew over road, high speed
1996	? Oct.	Tawny Owl *Kattuggla*	Tvedöra, Skåne	Paved Broad	Farmland	flew up from roadside with rodent, dark, low speed***
1997	12 March	Domestic Duck *Tamanka*	Södra Sandby, Skåne	Town Street	Buildings, park	Landed on road in front of car, low speed
1997	18 May	Thrush Nightingale *Näktergal*	Veberöd, Skåne	Paved Broad	Forest	passed over road before dawn, low speed

* The bird unconscious for some minutes, when released it flew away, probably in bad condition, but it may have survived. *Fågeln medvetslös några minuter, flög när den släpptes, troligen i dålig kondition, men kan ha överlevt.*
** Sat on road in rain, drove over it, wet, taken into the car, released dry on site after two hours, flew into a bush, possibly in bad condition, but may have survived. *Satt på vägen i regn, körde över den, våt, togs in i bilen, släpptes torr efter två timmar, flög in i buske, möjligen i dålig kondition, men kan ha överlevt.*
*** Flew up from road-side holding a rodent in claw, hit hard by upper edge of car, search in dark and next morning negative, possibly survived but likely wounded, or taken by scavenger during night. *Flög upp ur diket med en sork i klorna, slog hårt emot bilens överkant, letande i mörker och nästa morgon utan resultat, överlevde möjligen men troligen skadad, eller tagen av djur under natten.*

Willow Warbler on 16 June 1992 (Table 1) was discovered in the radiator grill of the car after a drive from Abisko to Ammarnäs (640 km). It would not have been recorded if it had not got stuck there. Another possible source of error, tending to reduce the number of kills, is the increasing care of driving that I may have been applying, intentionally or unintentionally, when observing birds on the road or along the roadside. I have a feeling that I actually did pay more attention to the birds after having begun my record-keeping of the collisions. An average driver probably does not even observe the birds on the road and hence does nothing to avoid a collision.

The kill total that I have arrived at is much higher than the estimate of Göransson et al. (1978). But the two figures cannot be directly compared since the volume of road traffic has increased much since 1975. The number of vehicles increased from c. 2,500,000 in 1975 (Statistiska centralbyrån 1976) to c. 4,000,000 in 1995 or with a factor of about 1.6. Also the average number of kilometres driven by the cars has increased, but I have no data on this. However, it is likely that the combined factor is rather close to 2. That would mean that an estimate with the method of 1975 would have been 1–2 million birds if made today. This figure is still almost an order of magnitude smaller than my estimate.

In spite of the fact that my sample is very small, in fact only one (one person), I think that the great difference may indicate that the method of estimating traffic kills by collecting dead birds along the roads seriously underestimate the real toll.

It is known that dead birds disappear fast from the roads. They are taken by different scavengers and predators such as crows, gulls, kites, and buzzards and at night also by mammals. One experimental study by Stewart (1971) showed that 90% of dead House Sparrows thrown out from a car window onto the road pavement disappeared within 90 minutes, and that all of them had disappeared completely within two hours. Another experiment by the same author, involving 20 House Sparrows thrown onto the road surface gave the following result. All the birds on the road had been crushed between forenoon and evening but remained visible. But the next morning all traces of them had disappeared.

Aware of this Göransson et al. (1978) made a calibration study by patrolling their intensive study road every two hours during two months. They found correction factors of 3.6 for small passerines and 2.3 for larger birds. However, they were not able to correct for birds that did not stay on the road, i.e. birds that were blown off the road or flew away and died later. This proportion is still unknown.

From this discussion it is obvious that it is difficult to determine how generally valid my records are, but they take account of some of the deficiencies in the traditional method of counting dead birds on the road surface. I have been driving in many countries over the years but without keeping any record of bird collisions. However, some comparatively recent drives may be used, since I can recall the bird collisions. During two visits to South Africa, I drove just a little more than 10,000 km, which resulted in one collision. It was a Lilac-breasted Roller *Coracias caudata* that suddenly dove from a vantage point to pick up a larger insect from the road just in front of the car. (Interestingly, when I had stopped I saw in the mirror only a short distance behind the car the roller while still moving its wings somewhat to be immediately attacked by two Burchell's Starlings *Lamprotornis australis*. The feathers of this roller now decorate the 1998 front cover of *Journal of Avian Biology*!) In North America, mainly the United States, I have also been driving about 10,000 km in recent years with one bird killed. It was a Northern Cardinal *Cardinalis cardinalis* that was decapitated by the radio antenna when trying to fly over a very narrow dirt road where the branches of the trees repeatedly touched the car. This is roughly one bird per 10,000 km, exactly the same as in Sweden, so my estimate may perhaps have a rather general value.

As already said, it is difficult to draw any conclusions about the conditions during which it is most likely to kill a bird by the car. I have no record about the proportion of different road types or surrounding habitats of my driving, and it is not possible to reconstruct this. However, I am rather confident that the number of killed birds at low speed is much higher than the proportion of kilometres that I have driven with low speed. With low speed I mean below about 50 km/h and with high speed anything above. Of the 27 cases for which I made a record of or recollect the speed, 16 (59%) occurred when I was driving slowly. I would guess that the proportion of the total number of kilometres that I have been driving with low speed does not exceed 25%. The explanation to this is either that collisions are more unlikely to occur on larger roads where one drives faster or that it is more difficult to observe a collision when driving fast. If the latter is the case several collisions may have been missed and my estimate is too low.

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Sammanfattning

Fågeldöd på vägar: är denna dödsorsak allvarligt underskattad?

Jag har använt mig av ett nytt sätt för att uppskatta hur många fåglar som dödas av trafiken på vägarna, nämligen att registrera de kollisioner med fåglar som jag själv varit med om. Därefter har jag räknat om antalet till den totala trafikvolymen i Sverige. Den siffra jag kommit fram till är nästan tio miljoner fåglar, vilket är en storleksordning högre än en tidigare uppskattning baserad på räkning av dödade fåglar på vägbanan. Det är därför möjligt att vi grovt underskattat trafiken som dödsorsak.

På sjuttiotalet genomfördes en omfattande studie av vägars inverkan på omgivande natur och man uppskattade antalet trafikdödade fåglar till ca. 500.000, högst en miljon. Omräknat till dagens ungefär fördubblade trafikvolym ger samma beräkningsmetod ett aktuellt tal på mellan en och två miljoner fåglar.

Mellan 22 oktober 1989 och 21 oktober 1998, d.v.s. under nio år, kolliderade jag med 29 fåglar (Tabell 1). Under denna tid körde jag 288.000 km (32.000 km per år). Det innebär 3,22 fåglar per år och nästan exakt en fågel per 10.000 km. År 1995 fanns det 3.631.000 personbilar och 323.000 lastbilar och bussar. Räknat på genomsnittliga körsträckor om 18.000 km för personbilar och 62.000 km för lastbilar och bussar blir den årliga totala körsträckan 85.384.000.000 km. Med en dödad fågel per 10.000 km blir summan ungefär 8,5 miljoner fåglar. En genomsnittlig personbilsförare bör därför uppleva ungefär 1,8 fågelkollisioner per år, de flesta dock färre eftersom mediankörsträckan är 14.000 km.

Nyckelfrågan är naturligtvis om jag är en genomsnittlig bilförare och kört ett representativt stickprov av det svenska vägnätet. Min årliga körning har bestått av ca 10.000 km mellan Torna Hällestad och arbetet i Lund, ca 15.000 km mellan Lund och Ammarnäs, Abisko och många andra fältarbetsplatser över hela landet, resten diverse körningar i södra Sverige. Jag har aldrig fört någon statistik över typen av vägar jag kört på och kan därför inte korrigera för detta i förhållande till olika vägtypers längd i landet. Inte heller kan jag korrigera för andra faktorer som kan påverka antalet kollisioner: årstid, tid på dygnet, biotoper i omgivningen, m.m.).

Jag tror inte att det är någon risk att min beräkning är en underskattning av antalet kollisioner. En del kollisioner måste ha missats. I flera fall har fåglarna flugit ut på låg nivå framför bilen och sådana kollisioner missas lätt. Exempelvis hittade jag den 16 juni 1992 en lövsångare i grillen efter en körning från Abisko till Ammarnäs. Den hade aldrig blivit registrerad om den inte fastnat. En annan faktor som bidrar till att ge en underskattning är att jag tycker mig ha blivit successivt försiktigare när jag upptäckt fåglar på eller nära vägen. En genomsnittlig bilist, som inte som jag är direkt uppmärksam fågelkollisioner, ser förmodligen inte ens dessa fåglar och gör inget för att undvika kollision.

Orsaken till att det blivit så stor skillnad mellan min och den tidigare uppskattningen är förmodligen att döda fåglar försvinner mycket hastigt från vägbanan. De tas av kråkfåglar, måsar, vråkar och glador och nattetid även av däggdjur. Amerikanska studier visar att det ofta rör sig om timmar innan alla spår av fåglar är borta. Patrullering av vägar för att räkna överkörda fåglar ger därför lätt en kraftig underskattning av det verkliga antalet dödsfall. Därtill bidrar också de fåglar som blåser av vägen eller flyger iväg skadade och senare dör och som inte alls kommer med i summorna.

Om min uppskattning är något i underkant kan det totala antalet fåglar som årligen dödas av bilar på våra vägar vara ungefär tio miljoner. Det är ungefär samma antal som dödas av katter varje år. Biotopförändringar är givetvis den främsta orsaken till antalsförändringar i fågelvärlden, men tillsammans kan kanske olika mera marginella dödsorsaker som katter och bilar också ha en märkbar påverkan, i varje fall lokalt.

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