Road kills: Assessing insect casualties using flagship taxon

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Roads and traffic are the central features of human development, but a severe threat to forest and wildlife. In this study we have assessed the extent of insect road kills in two national parks and a suburb-scrubland. The diversity and abundance of insect casualties were enumerated and compared across sites. Dragonflies and butterflies were the major insect kills with higher casualties on Sunday, which is associated with increased traffic load. Butterfly road kills were represented by high species diversity. This study reveals severity of invertebrate/insect casualties on road, conservation needs and surprising new frontiers of road ecology.

Keywords: Butterflies, insects, national parks, road ecology, road kills.

ROADS are a widespread and increasing feature of most landscapes, and an integral part of human development and sustenance. In India, for example, there was about eight-fold increase in the total length of roads (from 0.399 to 3.38 million km) and 100-fold increase in the number of motorized vehicles (from 0.3 to 30 million, with a growth of ~ 12% per annum) in the last 50 years (1951–2004)[1]. Human casualties occur daily on roads as a consequence of increased usage and growing traffic (growth rate of 7 to 10% per annum in India)[1] and therefore, reducing deaths and injuries is the primary and growing concern of road safety.

Apart from this gloomy outcome, they have great but apparently benign ecological consequences, i.e. increased mortality of animals and plants, habitat loss from road construction, alteration of the physical and chemical environment, and changes in roadside wilderness. Roads alter landscape spatial pattern and interrupt horizontal ecological flows strongly. The great impact on animal population includes road kills, limiting population, road avoidance causing home-range shift, modification of movement pattern and barrier effect subdividing habitat and populations[2].

Wildlife casualties occur virtually every minute and are higher than ever before because roads dissect all forest patches rendering them to much functional fragmentation. There is no international or national statistics documenting these events. In India, major roads, more commonly highways and heavy traffic pass through almost every national park and protected area – the last remains of fragile wild habitats[3] and their impact in the form of road kills are virtually unknown. In a follow-up at Palamau Tiger Reserve, Jharkhand between 1997 and 2002, the Wildlife Protection Society of India has recorded as many as 24 leopards (*Panthera pardus*), five tigers (*Panthera tigris*) and 50 other wildlife species' road kills[3]. Similarly, in Vadodara (Ahmedabad) 16 leopards, 50 hyena (*Hyaena hyaena*) and 46 blue bull (*Boselaphus tragocamelus*) road kills have been reported[4] between 1998 and 2004.

Research on wildlife road casualties and ecology is limited and the existing literature is largely focused on vertebrates, mostly large mammals[5–14]. With a few studies on invertebrates[15], one can only guess the extent of road casualties and their ecological consequences on the vast majority of invertebrate species, especially insects. This difference in the study is largely due to the vagaries of intellectual fashion, and most certainly does not reflect the relative importance of vertebrates versus invertebrates in maintaining the structure and function of ecosystems[16]. For instance, fragmentation of invertebrate/insect population and restriction of their movements due to roads and traffic may have much severe long-term consequences on gene flow and population dynamics of forest plants as almost half of them are insect-pollinated and a vast majority of insects are phytophagous. Most known insect species have just a 'name' and we know nothing about their ecology, let alone the effect of roads and traffic. A systematic study on invertebrate/insect road kills and ecology is thus an urgent need to understand their present scenario and prioritize the conservation needs. Therefore, keeping these points in mind, we looked at the occurrence and extent of insect casualties on roads at two national parks and a suburb-scrubland and present the results here.

Insect road casualties were monitored between August and November 2005 at three sites, namely Bandipur National Park [12.7 km, Mysore–Bandipur (11°40′34″N, 76°38′20″E) – Ooty route; dry deciduous forest], Nagarahole National Park [10.2 km, Mysore–Titimati (12°13′26″N, 76°01′28″E) – Virajpet route; dry/moist deciduous and mixed forest) and Ring road, Mysore [15.6 km, double road intersecting Mysore–Bangalore route, Mysore–Mahadevapura route (12°20′34″N, 76°41′07″E) and Mysore–Bannur route; countryside/suburb–grass/scrub-land] (see Figure 1).

Traffic load was quantified between 11 : 00 am and 12 : 00 noon on Sunday (3) and weekdays (3). All vehicles plying either side were considered.

Roads were surveyed between 12 : 00 noon and 2 : 00 pm on Sunday (3) and weekdays (6) at these sites (a total of 27 sampling days). The entire stretch of road was covered by slow riding (~20 km speed) on bike; road and road sides were visually searched for any insect casualties. All insect kills were identified/assigned to order level and butterfly kills were identified to species level (Figure 2). Wherever possible, kills were removed from the road to eliminate the possibility of overcounting on the following day (for survey on Sunday a similar exercise was made the previous day).

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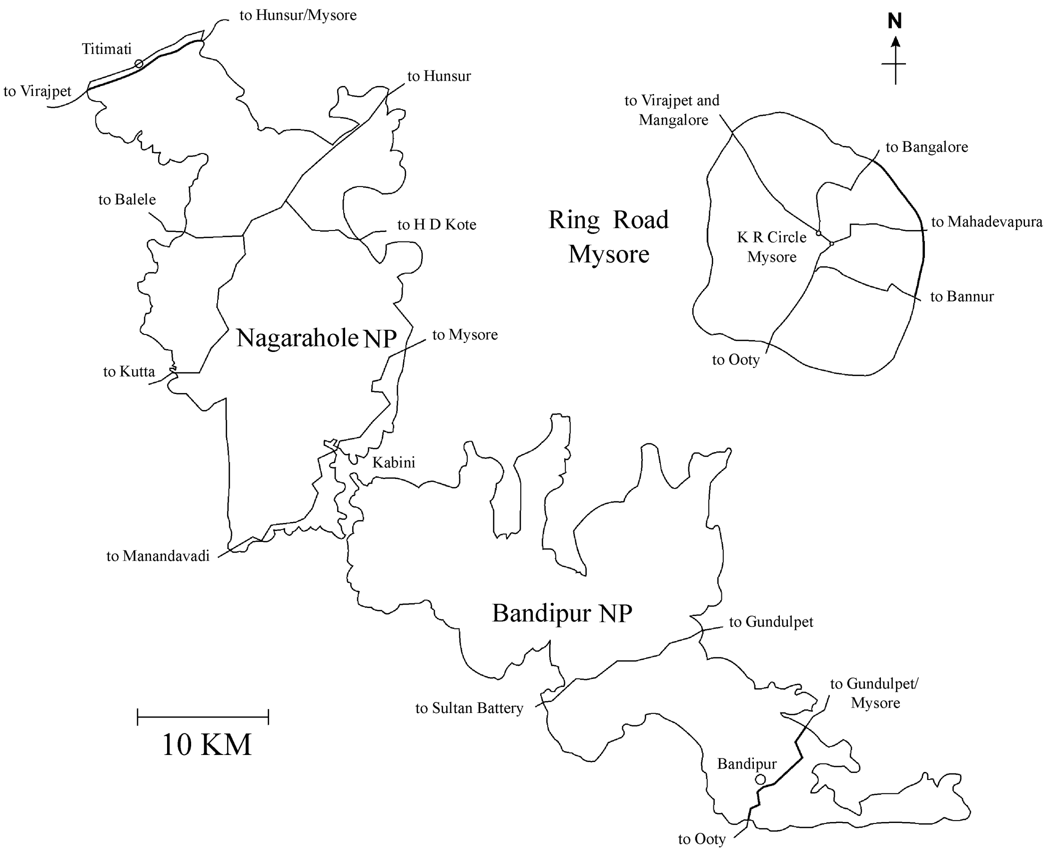

Figure 1. Maps of three study sites – Bandipur National Park, Nagarahole National Park and Ring road, Mysore. Major road networks within the national parks are shown and three study roads are marked as thick lines. For geo-coordinates and other details see text (distance between Ring Road, Mysore and the national parks is not to scale).

At these study sites, butterflies were censused along nine 500 m long-line transects (distantly located road-side stretches representing the entire study site) between 9 : 00 and 11 : 00 am on three days. The transect-line was walked past slowly and butterflies seen were recorded[17–19].

Percentage of kills in each order is represented in the form of a pie diagram. Road kill densities (number of kills per day per km) of all insects and lepidopterans on Sunday and on weekdays were calculated. Representation of butterfly species in road kills and transects and their distribution across the study sites were enumerated. Since the sample size was unequal at the three sites, rarefied richness was estimated using rarefaction[20] for two sets – road kills and transects. In addition, α-diversity of butterfly species in two sets for three sites was calculated in terms of Shannon and Simpson indices[18,21]. Species evenness and proportion of unshared species across sites (β-diversity) were also calculated for the two sets[18,21].

The traffic load in three study roads was quantified between 11 : 00 am and 12 : 00 noon – a usually high activity period for insects/butterflies[17,18] and is shown in Figure 3. Bandipur, being an inter-state highway, had less vehicle volume (47.3 ± 7.8 vehicles/h), which is more in Nagarahole (90.0 ± 12.8 vehicles/h) and highest at the Ring road (122.3 ± 11.7 vehicles/h). However, vehicle volume on these roads increased significantly (χ^2 test) on Sunday and the increase was highest in Bandipur (166.4%) followed by Nagarahole (136.0%) and Ring road (127.0%; Figure 3). Trucks, buses, cars and bikes are the main vehicles plying on these roads. Increase in vehicle volume on Sunday, mainly in Bandipur, is due to tourist activity/vehicles, plying to Ooty, a famous tourist spot. The possible daily, seasonal and annual variation patterns in vehicle volume on these roads need to be looked at further in the road-kill perspective.

A large number of insect casualties has been observed on roads (Figure 2). During the study period, a total of 1269 individual insects were found as road kills in three study sites and were assigned to nine orders (Figure 4). Mortality was highest in dragonflies (Odonata, ~ 61%) and butterflies (Lepidoptera, ~ 35%, with only three moth kills) and other orders represented only ~ 4% of the kills. Insects, especially dragonflies[22] and some butterflies[17,18], may be seen flying in the open habitats/forest clearings; and roads being open places, may particularly attract these insects, rendering them prone to road casualties. Road-kill data present interesting ecological and behavioural information on animals[2,14]. For example, raccoon dogs are particularly

Figure 2. Road kills: ***a***, Road-side sign-wall (message – 'make passage for wildlife to cross the road, move slowly, speed limit 40 km') at Bandipur National Park; ***b***, Mating grasshoppers on road; ***c–q***, Butterflies: ***c***, Yellows and Blues at road-side; ***d***, Recovering male (left) of a Yellow mating-pair after being hit by a truck, ***e***, Dead Crimson Rose; ***f***, Common Rose; ***g***, Male Common Mormon; ***h***, Female Common Mormon; ***i***, Male Danaid Eggfly; ***j***, Female Danaid Eggfly; ***k***, Male Plain Tiger; ***l***, Female Plain Tiger; ***m***, Common Grass Yellow; ***n***, Yellow Orange Tip; ***o***, Dark Blue Tiger; ***p***, Common Indian Crow and ***q***, Mottled Emigrant. ***r***, Bug; ***s***, Carpenter bee; ***t***, Dragonfly; ***u***, Frog; ***v***, Lizard; ***w***, Jungle Babbler; ***x***, Rodent.

killed on roads passing through broad-leaved woodland[13] and small vertebrates are killed on roads close to vegetation cover[8]. Similarly, in case of reptiles, road kills were highest in wet forest, to which they are most attracted[12] and female turtles are particularly attracted to open habitats such as roads for egg-laying, but are killed on their way[5].

It is worthwhile to note that road kills were largely represented by dragonflies and butterflies perhaps because of their high visibility. High mortality among dragonflies and butterflies could also be due to their peak seasonality in occurrence and migration. Other insect orders too might be equally numerous, however, their largely dull colour and small body size (like many bees, wasps and beetles) limit their visibility on the road. Moreover, road kills of many other small insects like ants (Hymenoptera), plant/leaf hoppers (Homoptera), termites (Isoptera) and small flies/mosquitoes (Diptera) may be innumerable, however, they could not be considered in this study because they are practically invisible. Perhaps there may be no chance of ants and many other insects crossing the road with such a high vehicle volume (47–155 vehicles/h; Figure 3). A study showed that in a road with similar vehicle volume (134 vehicles/h) frogs had a high probability (0.89 to 0.98) of getting killed[11]. Therefore, here Odonata and Lepidoptera kills should be taken as a 'trend-index'[13] of high insect road casualties (Figure 2). The present data, however, chiefly represent diurnal road casualties. Nocturnal insect casualties, on the other hand, may be much higher as they are particularly attracted to bright lights of vehicles. However, here they are not studied as many of the nocturnal insects like flies/mosquitoes (Diptera), plant/leaf hoppers (Homoptera), moths (Lepidoptera) and termites (Isoptera) are active in late evening/night and are difficult to sight on the road due to their small size and obscure coloration.

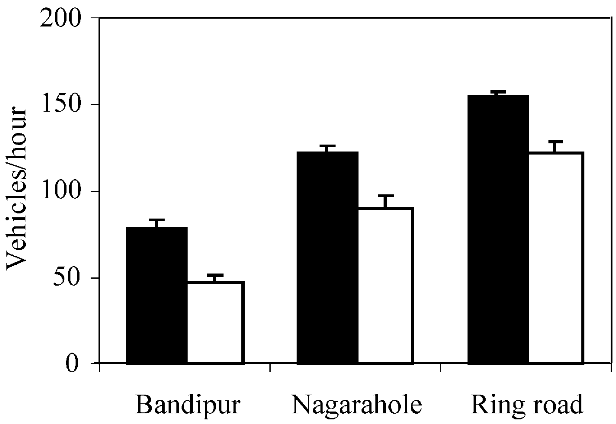

Figure 3. Traffic load (from 11:00 am to 12:00 noon – during the period of high insect activity) at three sites. Traffic load on Sunday (black column) is significantly higher compared to weekdays (white column) at all three sites (Bandipur: $\chi^2 = 7.34$, $P < 0.025$; Nagarahole: $\chi^2 = 4.73$, $P < 0.05$; Ring road: $\chi^2 = 3.69$, $P < 0.1$; Yates correction incorporated).

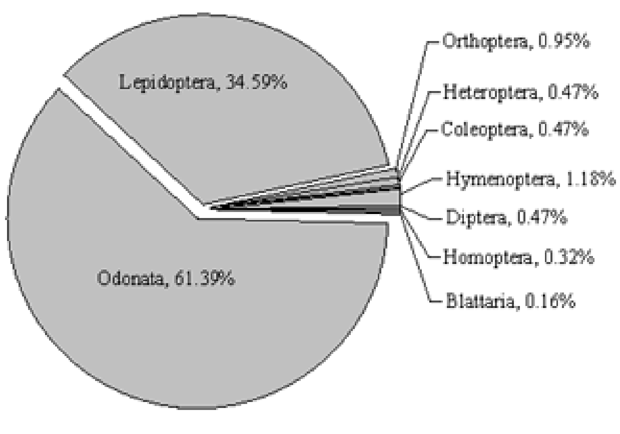

Figure 4. Percentage of insects ($n = 1269$) belonging to different orders killed on the road by passing vehicles at three sites (pooled). Ants (hymenoptera), small flies/mosquitoes (Diptera), leaf/plant hoppers (Homoptera) and termites (Isoptera) are not included (see text for explanation).

Figure 5 shows the proportion/ratio of dragonfly and butterfly road kills on Sunday and on weekdays in the three study sites. Proportion of these insects remained almost the same on Sunday and on weekdays for a given site. This may be an indication of the relative abundance of these insects and possible habitat conditions of a given site. In Bandipur, being a much open habitat, dragonflies were abundant (64.5%) and Nagarahole being moist while mixed forest with higher canopy cover, had slightly lower proportion (57.9%) of dragonfly road kills. Being an open habitat, the ring road too had a much higher proportion (63.0%) of dragonflies in road kills. However, the unequal ratio of dragonfly and butterfly road kills found on Sunday and weekdays in this site may be due to variation in the climatic conditions (during the study at this site, weekdays were slightly cloudy, affecting the dragonfly flight/behaviour), which is not taken into consideration in this study. Climatic conditions are known to affect the behaviour of insects[17,18] and other animals, in turn affecting the extent of road kills[12,13]. A list of road-killed butterfly species and some of the dragonfly species is provided in Appendices 1 and 2 respectively.

Road-kill density of all insects and lepidopterans alone is presented in Figure 6. Insect and lepidopteran road-kill densities widely varied (1.6–8.01 kills/day/km for insects and 0.45–3.11 kills/day/km for lepidopterans) in the three study sites. This trend could be explained on the basis of vehicle volume and butterfly abundance/diversity. Although the ring road had high vehicle volume (Figure 3), butterfly abundance and diversity were very low (Appendix 1; Table 1). This led to low insect/lepidopteran road-kill density at this site. Although butterfly abundance/diversity was high at Bandipur (Appendix 1; Table 1), low vehicle volume (Figure 3) led to the intermediate level of insect/lepidopteran road kills. Butterfly abundance/diversity (Appendix 1; Table 1) and vehicle volume (Figure 3) both being high, Nagarahole witnessed the highest insect/lepidopteran road casualties.

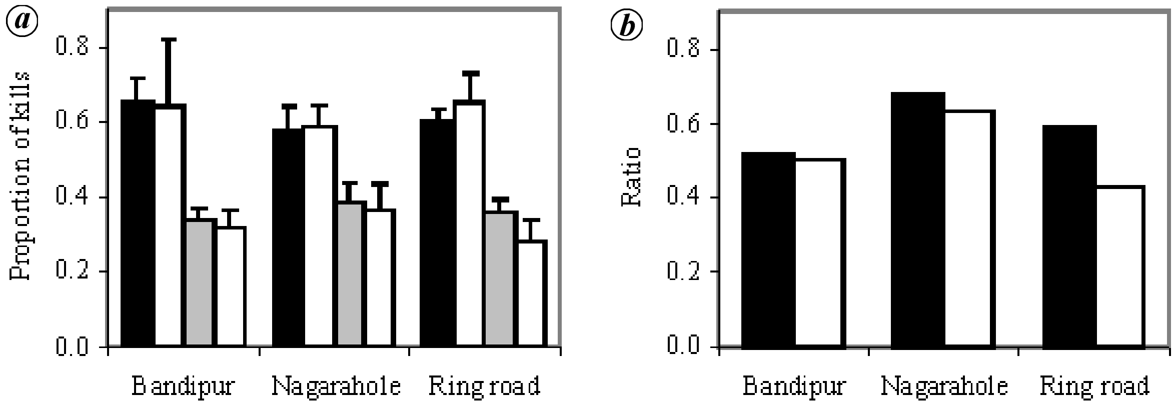

Figure 5. Proportion of dragonflies and lepidopterans on Sunday (black and grey columns) and on weekdays (dotted and white columns) at three sites (***a***) and ratio of lepidopterans versus dragonflies on Sunday (black column) and on weekdays (white column) at three sites (***b***).

Table 1. Diversity attributes of butterfly road kills and transects at the three sites

	Richness	Rarefied richness	Alpha diversity		Beta diversity	Evenness
			Shannon's	Simpson's		
Road kills						
Bandipur	30	24.5	2.4	0.82	0.12	0.71
Nagarahole	51	35.3	3.19	0.91	0.21	0.81
Ring road	14	14	1.63	0.71	0.16	0.62
Transects						
Bandipur	42	24.9	2.68	0.84	0.34	0.72
Nagarahole	53	32.7	3.48	0.95	0.43	0.88
Ring road	18	18	2.41	0.87	0.38	0.83

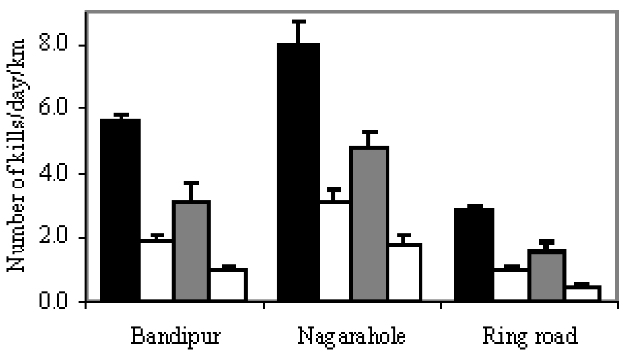

Figure 6. Road-kill density at the three sites: all insects (black column) and lepidopterans (dotted column) on Sunday, and all insects (grey column) and lepidopterans (white column) on weekdays. Road kills (total) on Sunday are significantly higher compared to weekdays (Bandipur: $\chi^2 = 8.85$, $P < 0.005$ (insects), $\chi^2 = 2.91$, $P < 0.1$ (lepidopterans); Nagarahole: $\chi^2 = 7.86$, $P < 0.025$ (insects), $\chi^2 = 3.33$, $P < 0.1$ (lepidopterans); Ring road: $\chi^2 = 4.55$, $P < 0.05$ (insects), $\chi^2 = 2.6$, $P < 0.25$ (lepidopterans); Yates correction incorporated).

Interestingly, both insect and lepidopteran road kills (total) were significantly higher (χ^2 test) on Sunday (167.8–182.2% insect kills and 177.6–223.9% lepidopteran kills) compared to weekdays in all three sites (Figure 6). This is correlated to significantly higher vehicle volume on Sunday (127.0–166.4%) in these sites (Figure 3). Insect/lepidopteran road-kill densities are substantial compared to the snake road kills reported (5.22 kills/km annually)[12]. High densities of road kills may be typical for invertebrates such as butterflies[23] and crabs[15].

The abundance and diversity of butterfly road kills in the three sites are given in Appendix 1 and diversity parameters are presented in Table 1. To know the actual diversity of butterflies, they were censused on line-transects at these study sites and the results are presented in Appendix 1 and Table 1. A total of 491 individuals were assigned to 59 species[19]. Butterfly species richness is highest in Nagarahole followed by Bandipur and the Ring road. Rarefaction showed a similar pattern, but lower richness for Nagarahole and Bandipur sites. It is interesting to note that species richness, rarefied richness and other diversity parameter patterns are nearly identical from site to site in road kills and transects (Table 1). We believe that road-kill patterns reveal the true nature of insect diversity of a given site. As the kills are dominated by few species like Grass Yellows and Emigrants (which show peak abundance during late monsoon period[17]), road-kills β-diversity has a lower value compared to transects (Table 1). Overall, roads in national parks had high butterfly diversity compared to Ring road/countryside as forests harbour a diversity of butterfly host plant species[18].

Many butterfly species found in transects (like Southern Birdwing and Clipper) were not found as road kills due to their varied niche and behaviour. They are not prone to traffic casualties as they escape vehicular hit by flying high in the canopy. Similarly, species like Psyche that fly low among bushes, and Orange Tips, that are agile fliers also escape road casualties. Species such as Grass Yellows and Emigrants, which either fly low or congregate and mud puddle on road-sides are prone to road casualties. However, it may be noted that road kills represented many species (such as Common Nawab and Common Wanderer) were not found in the transects (Appendix 1). This clearly indicates the severity of road and traffic on the casualties of apparently rare butterfy species as well. Butterflies may thus be considered as a flagship taxon to assess the insect casualties in a much broader road-ecology perspective.

It is interesting to note that among three species of road-killed butterflies where their sex could be easily identified, male individuals were higher in number. In Common Mormon (*Papilio polytes*), this difference is not high, but in Danaid Eggfly (*Hypolimnas misippus*) and Plain Tiger (*Danaus chrysippus*), the number of male road kills is significantly higher (χ^2 test) (Figure 7). Sex-biased road kills may occur due to behavioural differences and varied needs of sexes as known to occur in animals like male koalas[7] and female turtles[5]. In butterflies, although females are mobile during the egg-laying period and seen flying near larval food plants, males are particularly mobile in open places (or may be holding territory) in search of females. We have witnessed a strange behaviour in which males are seen mating with the road-killed females and in many cases become road kills themselves. We present two untested hypotheses: males may be either visually attracted to dead females on the road or are attracted to road-killed females due to their sex-specific pheromone-like chemicals released during crushing of the female body. These hypotheses need to be tested. On the other hand, this sex difference in the road kills of these three butterfly species may simply reflect their population sex ratio, which we did not determine in this study, but needs to be considered in future.

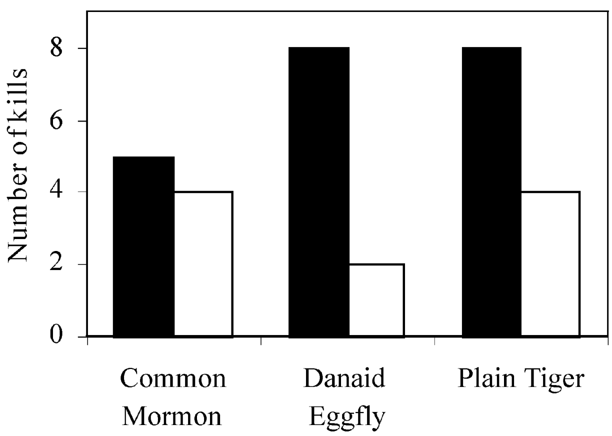

Figure 7. Male (black column) sex-biased road kills in Common Mormon (χ^2 test not performed), Danaid Eggfly ($\chi^2 = 3.6$, $P < 0.1$) and Plain Tiger ($\chi^2 = 1.33$, $P < 0.5$; for three species pooled: $\chi^2 = 3.23$, $P < 0.1$, Yates correction incorporated). Population sex ratio not determined.

Insect activity may be present on the road or roadsides (Figure 2 *b* and *c*) or insects may be seen crossing the road to get into other forest patches. Unlike most of the animal road kills (like snakes), wherein they are hit and/or run over by vehicles in one go, most of the flying insect road kills occur in two steps. First, insects flying across the road are hit by speeding vehicles. We have observed that vehicle speed of 30–40 km/h (which is advocated, Figure 2 *a*) is safe for flying insects. However, at higher vehicle speeds (50–60 km/h) insects experience severe shock/trauma upon being hit. They fall on the road, recover from the initial trauma and struggle to fly (Figure 2 *d*). In rare occasions they may fully recover and fly away, but in most cases they are once again hit and/or run over by the next passing vehicle.

During the present study we have also encountered some vertebrate road kills, such as amphibians (7 kills), reptiles [lizards (11 kills) and snakes (6 kills)], birds (2 kills) and mammals (2 kills; Figure 2). We have witnessed insect road kills being picked up by a wide range of animals like lizards, birds (like crows, mynas and babblers) and mammals (macaques and mongoose) as food. This is an extraordinary type of food chain and possibly leads to the road kill cascade as animals seeking food on the road are particularly prone to road casualties. This may be the likely reason for the observed high number of lizard road kills, which are particularly attracted to the struggling insects on road, in turn attracting snakes and birds. This also suggests that the observed road-kill density may be much less than the actual value as the road-killed insects are likely to be scavenged soon by other animals. Thus the insect road kill study has much wider road ecological perspective.

To minimize road kills we emphasize some points which need to be considered in future: speed limit of vehicles passing through national parks – at least in some road stretches, construction of some over-bridges and underpasses to make room for wildlife, especially insect movement and most important, awareness programmes for drivers and the general public on road ecology. Maintaining the continuous population of insects like butterflies, bees, wasps and beetles may be crucial to maintain the forest structure and dynamics, as insects are pollinators and herbivores of majority of the forest trees. This will ensure the gene flow among trees and insect populations alike, in turn keeping the ecosystem healthy.

Invertebrates, insects in particular, are prone to high road casualties. Road-killed species are a good representation of the actual diversity of species in a particular site. Insects/invertebrates are important ecologically[16]. Therefore while monitoring ecological/environmental impact of roads and

Appendix 1. Common name and scientific name of butterfly species and their representation in road kills and transects at the three study sites

		Road kills				Transects			
Common name	Scientific name	A	B	C	ABC	A	B	C	ABC
Family: Papilionidae (Swallowtails)									
Blue mormon	*Papilio polymnestor*	–	+	–	+	+	+	–	+
Common bluebottle	*Graphium sarpedon*	+	+	–	+	–	–	–	–
Common mormon*	*Papilio polytes*	+	+	+	+	+	+	–	+
Common rose	*Pachliopta aristolochiae*	+	+	+	+	+	+	+	+
Crimson rose	*Pachliopta hector*	+	+	–	+	+	+	+	+
Lime	*Papilio demoleus*	+	+	–	+	+	+	–	+
Red helen	*Papilio helenus*	–	–	–	–	+	+	–	+
Southern birdwing	*Troides minos*	–	–	–	–	–	+	–	+
Tailed jay	*Graphium agamemnon*	+	+	–	+	+	+	+	+
Family: Pieridae (Whites and Yellows)									
Common emigrant	*Catopsilia leda*	+	+	–	+	+	+	–	+
Common grass yellow	*Eurema hecabe*	+	+	+	+	+	+	+	+
Common gull	*Cepora nerissa*	–	+	–	+	+	–	–	+
Common jezebel	*Delias eucharis*	+	+	–	+	+	+	+	+
Common wanderer	*Pareromia valeria*	–	+	–	+	–	–	–	–
Great orange tip	*Hebomoia glaucippe*	–	–	–	–	+	+	–	+
Mottled emigrant	*Catopsilia pyranthe*	+	+	+	+	+	+	+	+
Pioneer	*Anaphaeis aurota*	–	+	–	+	+	–	–	+
Psyche	*Leptosia nina*	–	–	–	–	+	+	–	+
Small orange tip	*Colotis etrisda*	–	–	–	–	–	+	–	+
White orange tip	*Mcrianne laxias*	–	–	–	–	–	+	–	+
Yellow orange tip	*Ixias pyrene*	+	+	–	+	–	+	–	+
Family: Nymphalidae (Brush-footed butterflies)									
Angle castor	*Ariadne ariadne*	–	+	–	+	–	–	–	–
Blue pansy	*Junonia orithya*	+	+	–	+	+	–	+	+
Blue tiger	*Tirumala limniace*	–	+	–	+	–	+	–	+
Chocolate pansy	*Junonia iphita*	+	+	–	+	+	+	–	+
Clipper	*Parthenos sylvia*	–	–	–	–	–	+	–	+
Commander	*Limenitis procris*	–	+	–	+	–	–	–	–
Common bush brown	*Mycalesis perseus*	+	+	–	+	+	+	–	+
Common castor	*Ariadne merione*	–	+	+	+	+	+	–	+
Common evening brown	*Melanitis leda*	–	+	–	+	+	+	–	+
Common five ring	*Ypthima baldus*	–	+	–	+	–	–	–	–
Common four ring	*Ypthima huebneri*	–	+	–	+	+	+	–	+
Common Indian crow	*Euploea core*	+	+	+	+	+	+	+	+
Common leopard	*Phalanta phalantha*	–	+	–	+	–	–	–	–
Common nawab	*Eriboea athamas*	+	–	–	+	–	–	–	–
Common palmfly	*Elymnias hypermnestra*	–	–	–	–	–	+	–	+
Common sailor	*Neptis hylas*	–	+	–	+	+	+	–	+
Danaid eggfly*	*Hypolimnas misippus*	+	+	+	+	+	+	+	+
Dark blue tiger	*Tirumala septentrionis*	+	+	+	+	+	+	+	+
Glassy tiger	*Parantica aglea*	–	+	–	+	–	–	–	–
Great eggfly	*Hypolimnas bolina*	–	+	–	+	–	+	–	+
Grey count	*Tanaecia lepidae*	–	–	–	–	+	+	–	+
Grey pansy	*Junonia atlites*	–	+	–	+	+	+	+	+
Lemon pansy	*Junonia lemonias*	+	+	+	+	+	+	+	+
Nigger	*Orsotriaena medus*	+	+	–	+	+	+	+	+
Peacock pansy	*Junonia almana*	+	+	–	+	+	+	+	+
Plain tiger*	*Danaus chrysippus*	+	+	+	+	+	+	+	+
Rustic	*Cupha erymanthis*	+	–	–	+	+	+	–	+
Striped tiger	*Danaus genutia*	–	+	–	+	–	+	–	+
Tawny coster	*Acraea violae*	+	+	+	+	+	–	+	+
Yellow pansy	*Junonia hierta*	+	–	–	+	+	–	+	+
Family: Lycaenidae (Blues)									
Angle pierrot	*Caleta caleta*	–	+	–	+	+	+	–	+
Banded blue pierrot	*Discolampa ethion*	+	+	–	+	+	+	–	+
Common pierrot	*Castalius rosimon*	+	+	+	+	+	+	–	+
Common silver line	*Spindasis vulcanus*	–	+	–	+	–	+	–	+
Line blue (Common)	*Prosotas nora*	–	+	–	+	+	+	–	+
Pea blue	*Lampides boeticus*	–	+	–	+	+	+	–	+
Plains cupid	*Chilades pandava*	–	–	–	–	–	+	–	+
Red pierrot	*Talicada nyseus*	+	+	+	+	+	+	+	+
Rounded pierrot	*Tarucus nara*	+	+	+	+	+	–	–	+

(*Contd…*)

Appendix 1. (*Contd…*)

Common name	Scientific name	Road kills A	Road kills B	Road kills C	Road kills ABC	Transects A	Transects B	Transects C	Transects ABC
Family: Hesperiidae (Skippers)									
Common banded awl	*Hasora chromus*	–	–	–	–	–	+	–	+
Water snow flat	*Tagiades litigiosa*	–	–	–	–	–	+	–	+
Skipper sp. 1		–	+	–	+	–	–	–	–
Skipper sp. 2		+	+	–	+	+	+	–	+
Skipper sp. 3		–	+	–	+	–	+	–	+
Skipper sp. 4		–	–	–	–	–	+	–	+
Species not identified									
Unidentified sp. 1		–	+	–	+	–	–	–	–
Unidentified sp. 2		–	–	–	–	–	+	–	+
Unidentified sp. 3		–	–	–	–	–	+	–	+
Total individuals		143	200	89	432	207	213	71	491
Species represented (total 69)		30	51	14	54	42	53	18	59
Species found only in kills but not in transects						3	14	4	10

(+) Present, (–) absent, *Sex identified in road kills; A, Bandipur, B, Nagarahole, C, Ring road.

Appendix 2. Common name and scientific name of dragonfly species commonly found as road kills at the three study sites

Common name	Scientific name
Black marsh trotter	*Tramea limbata*
Blue darner	*Anax immaculifrons*
Blue-tailed green darner	*Anax guttatus*
Common club tail	*Ictinogomphus rapax*
Crimson marsh glider	*Trithemis aurora*
Crimson tailed marsh hawk	*Orthetrum pruinosum*
Fulvous forest skimmer	*Neurothemis fulvia*
Green marsh hawk	*Orthetrum sabina*
Ground skimmer	*Diplocodes trivialis*
Ruddy marsh skimmer	*Crocothemis servilia*
Rusty darner	*Anaciaeschna jaspidea*
Scarlet marsh hawk	*Aethriamanta brevipennis*
Wandering glider*	*Pantala flavescens*

*Wandering glider (*Pantala flavescens*) was the dominant species observed in road kills.

traffic, insect road kills, their consequences on gene flow and road–forest ecology also need to be considered.

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ACKNOWLEDGEMENTS. We thank Prof. N. V. Joshi and Dr K. A. Subramanian, IISc, Bangalore for discussion and suggestions. We also thank the anonymous reviewers for comments/suggestions on an earlier version of this manuscript.

Received 13 February 2006; revised accepted 24 October 2006