Greenbridges as crossovers for bats

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Introduction

Several studies have shown that large roads negatively effect bats, a highly protected species group. Bats are now regularly studied when impact assessments for new roads to be constructed are carried out. Besides an interruption of their flight path and the fragmentation of foraging habitats, the main problem is the collision with traffic (Häußler & Kalko 1991, Kiefer & Sander 1993, Lesinski 2007, Richarz 2000), especially for structure bound Myotis species that cross wide roads at a height of 0.5-4m. Therefore mitigation measures are necessary which enable bats to cross roads safely and which connect foraging habitats (AG Querungshilfen 2003, Bach et al. 2004, FGSV 2003, Limpens & Twisk 2004, Limpens et al. 2003). However, many of these mitigation measures have not yet been tested. In 2005, we tested the usefulness of greenbridges (originally constructed as mitigation measures for larger mammals) as mitigation measures for bats, (Pfister et al 1994).

Study area

The study sites were situated in two areas in Baden-Württemberg (southern Germany). Two of the investigated greenbridges (Hörnleswald and Aichelberg) and a bridge for a forestry road were situated ca. 40 km from Stuttgart (Fig 1). All other constructions (greenbridges, tunnels and ordinary road bridges) were situated at two roads (B31 new and B33 new) north of Lake Constance (Fig.1). All roads crossed by bridges or tunnels were four lane highways. The investigation was part of the project "FE-Vorhaben 02.220/2002/LR" financed by the German ministry of traffic.
The greenbridges as well as the other constructions were not originally designed for bats but for use by larger mammals. This means that neither the connections to the surrounding landscape nor the structures on the bridges were specifically designed for bats.

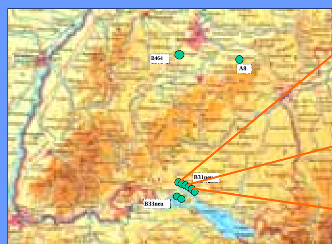
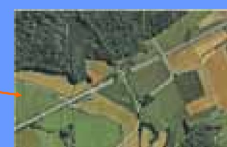


Fig. 1: distribution of the studied greenbridges

Weiherholz (medium valued example for a greenbridge)

Negelhof (bad valued example for a greenbridge)



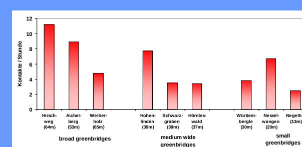
Hirschweg (good valued example for a greenbridge)

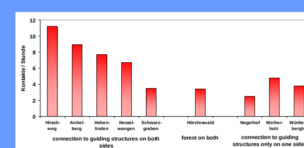
Material and methods

Surveys on greenbridges were carried out using a Pettersson D240x detector. Automatic registration systems ("bat boxes" containing SSF-heterodyne detector, Olympic Pearlcorder and a watch with hourly signal) were installed at all constructions. Placement options for bat boxes were limited, especially on the wide greenbridges. Therefore, it was not always possible to record all passing bats and we used only the survey data to compare bat activity between greenbridges.

Table. 1: typology of the investigated constructions

ROAD BRIDGES	*TYPE*			*BAT ACTIVITY / HOUR*	
				detector	Bat boxes
forest road crossing B 464	bridge for a forestry road			-	0,6
Haldenhof crossing B 31new	bridge for a local two lane road			-	1,4
Biblis crossing B 31neu	bridge for a local two lane road			-	2,1
TUNNELS	*TYPE*				
Bonndorfer Ried crossing B 31new	tunnel for a forestry road			-	4,1
Regentsweiler crossing B 31new	tunnel for a local two lane road			-	9,6
Löhrenbrunnen crossing B 31new	tunnel for a local two lane road			-	4,7
GREENBRIDGES	*TYPE*				
	WIDTH OF THE BRIDGE	*STRUCTURES ON THE BRIDGE*	*CONNECTIVITY TO SURROUNDING HEDGES*		
Weiherholz crossing B31new	65 m broad	bushes with gaps	one side close connection other side with gaps	4,8	3,7
Hirschweg crossing B31new	64 m broad	dense bushes	only on one side	11,2	8
Aichelberg crossing BAB A8	53 m broad	dense bushes	both sides close connection	8,9	2,4
Hohenlinden crossing B31new	39 m medium	bushes with gaps	one side close connection other side with gaps	7,7	3,5
Schwarzgraben crossing B31new	39 m medium	bushes with gaps	both sides close connection	3,5	2,3
Hörnleswald crossing B 464	37 m medium	only herbal vegetation	on both sides	3,4	2,5
Württembergle crossing B33new	30 m small	bushes with gaps	only on one side	3,8	-
Nesselwangen crossing B31new	20 m small	dense bushes	one side with gaps one side close	6,7	7,7
Negelhof crossing B 31new	13 m small	bushes with gaps	with gaps	2,5	0,8





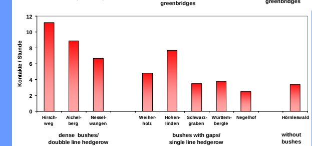


Fig.5:
Württembergle was planned without assessing the bat distribution in the sourroundings
(red arrow: a flight path of Pipistrelle bats)
Foto: Bertram Georgii

Fig. 4: comparison of bat activity on greenbridges in relation to bridge size, structures on the bridge and connection to the surroundings.

Comparison of the configuration of the greenbridges
The greenbridges differed in three main characteristics:
• width of the bridge
• connection to surrounding structures such as hedgerows which bats might use as guiding lines to the greenbridge and which therefore might improve the accessibility of the greenbridge for bats
• structures on the greenbridge itself which bats might use as guiding lines to cross the bridge and as hunting habitat.

We recorded higher bat activity at wider greenbridges (8.3 contacts/hour) than at medium sized (4.9 contacts/hour) or small greenbridges (4.3 contacts/hour). We recorded higher bat activity (8.9 contacts/hour) at greenbridges with dense structures or double rows of hedges than at greenbridges with scattered bushes (4,5 contacts/hour).
Bat activity at greenbridges which were relatively well connected to potential guiding structures on both sides (7.6 contacts/hour, five bridges) was higher than at bridges which had such a connection only one side (3.7 contacts/hour, three bridges) or which were surrounded by forest (3.4 contacts/hour, one bridge).

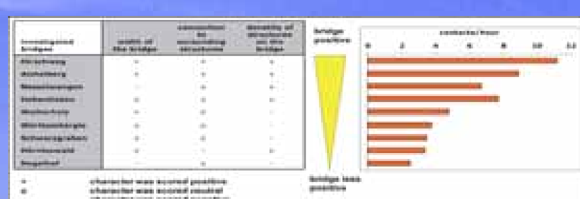


Fig. 6: rating of optimal or non optimal configuration of the bridges in comparison with the results of the detector survey

Results and Discussion

Species composition at the greenbridges
We recorded 11 bat species or species groups using the greenbridges. Of these, *Myotis nattereri*, *M. bechsteini* (suspected), *M. daubentoni*, *M. mystacinus/brandtii*, *M. myotis*, *Pipistrellus pipistrellus*, *P. nathusii* and *Plecotus auritus/austriacus* are usually bound to structures. We also registered *Nyctalus leisleri*, *N. noctula* and *Eptesicus serotinus*. In the following results we concentrate on species which are likely bound to structures, therefore excluding *Nyctalus* and *Eptesicus* species. All species were observed passing over and foraging on the greenbridges.

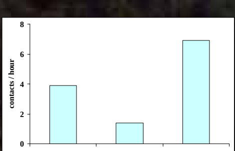


Fig. 2: mean value of contacts/hour/construction of three types of road crossings.
(confidence intervals: greenbridges (2,3 – 4,0) traffic road bridges (0,9 – 1,9) and underpasses (5,3 – 7,7) the differences in the activity of bats compared on the different construction types are significant (p<0,05, mean value test))

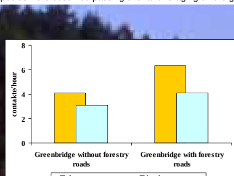


Fig. 3: bat activity at greenbridges with and without forestry roads

Bat activity was not significantly different between the narrow/ wide bridges, connectivity/ non-connectivity or dense/ scattered structures on the bridge. There are broad bridges with dense bushes and a good connection to the surroundings (Hirschweg) but also a middle sized bridge with scattered distributed bushes and a single line hedgerow and only a one side connection to the surroundings (Weiherholz). Due to a small sample size relative to the diversity of bridge characteristics, we did not carry out any further statistical tests. To visualize the differences between greenbridges we ranked them according to their characteristics (Fig. 6) and linked them with the results of the detector survey
Bridges, which were wide, well connected and had a high density of structures on the bridge had the highest bat activity (see also Britschgi et al. 2004, Bontadina et al. 2005) (Fig. 6). On the other hand, Weiherholz, a wide bridge with scattered bushes and a suboptimal connection to the surroundings showed a much lower bat activity. In contrast to that, a narrow bridge (e.g. Nesselwangen) with a good amount of structures on the bridge and well designed connections had a higher bat activity. That is important, if a construction should "only" connect an interrupted flight path on both sides of the road. The importance of the connection to the surroundings can be shown for Württembergle (see foto above), where the construction was optimal for the suggested function but the bridge was build 100m away from the right point and forced the bats to cross the road (Fig. 5). Structures on the bridge may be important for two reasons: 1. to guide bats over the bridge, 2. to reduce the impact of noise and light (see also Alder 1993, Billington pers. comm., RydellL & Racey 1995, (Schaub et al. 2008).

Comparison between greenbridges, tunnels and traffic road bridges
We found a higher bat activity on greenbridges than on ordinary road bridges within the same area (Fig. 2). Tunnels showed the highest bat activity. This might be because bats might perceive the embankment as a guiding structure to the tunnel entrance (see also Bach et al. 2004). Greenbridges were usually less well connected to hedgerows, tree lines, etc. than tunnels which might explain the lower usage of greenbridges by bats. Careful design might improve the effectiveness of greenbridges.

Comparison between greenbridges with and without forestry roads
Forestry roads don't seem to have had a negative effect on bat activity on the greenbridges as opposed to the activity of many other mammals. We found higher bat activity on greenbridges with forestry roads than without forestry roads using detectors. However, bat activity as recorded with bat boxes was not different between greenbrides with and without forestry roads.

Conclusion

The most important factors for a well built greenbridge seem to be good guiding structures on the bridge and a good connection to the surroundings. An optimal greenbridge should contain at least a double row of hedges and good connections on both sides if an established flight path should be preserved (see fig.7a). In forested areas bats might not establish flight paths but meet the street randomly. Here, wide greenbridges with dense structures on the bridge are necessary to keep the connectivity between seperated woodlands (see fig.7b).

Fig. 7a: an optimal greenbridge which leeds the bats over the street (drawing Peter Twisk)

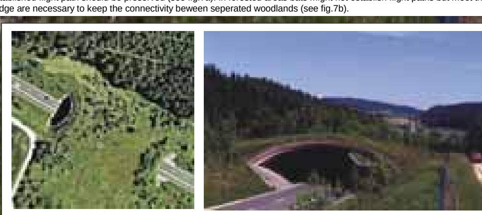


Fig. 7b: an optimal greenbridge to connect seperate woodlands

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