On the use of detection dogs for bat monitoring and research

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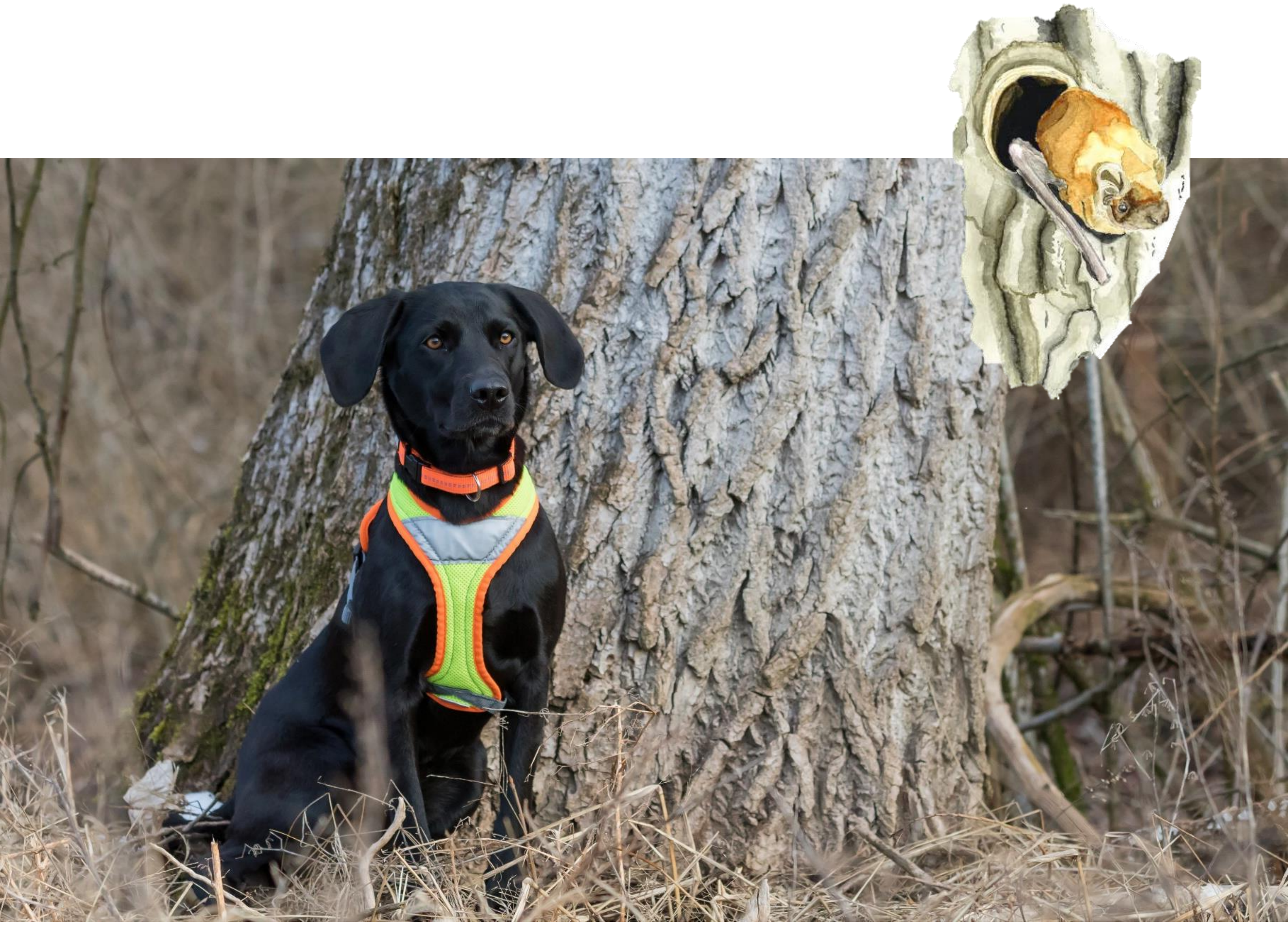
This study was conducted in collaboration with Stiftung Fledermausschutz Schweiz, StadtNatur, University of Freiburg im Breisgau, Wildlife Detection Dogs e.V.



Background & Review of literature

Many of the current methods in wildlife research and monitoring compromise the wellbeing and welfare of the studied individuals or the method is very time consuming and inefficient, all in order to gain much needed knowledge to protect entire populations and species (Soulé 1985). Considering animal welfare and the ongoing sixth mass extinction (Ceballos et al.2015, Pinillos et al. 2016), established methods that disturb or hampering individuals should be questioned (e.g. Costello et al. 2016) and ideally replaced by less harmful methods. Considering the 3R principles replace, reduce and refine; new methods in wildlife biology need to be developed to increase the welfare of the studied individuals. A promising and emerging low-impact method is the use of detection dogs to detect and survey wildlife. Trained dogs can efficiently search for a particular or multiple species and keep the disturbance to a minimum by eliminating the need of handling any individual while producing valuable data for conservation purposes. Thus, the method may be a solution for collecting data in a less disturbing and in a more efficient way.

For example, the use of telemetry transmitters always requires the handling of individuals which can be very stressful for animals (Wilson & McMahon 2006), influence feeding behavior, cause skin lesions, affect body mass and impair movement (Brooks et al. 2008, Coughlin et al. 2015, Field et al. 2012, Indermaur et al. 2008). Such stress can lead to reduced fitness and higher mortality.

The use of detection dogs is an innovative and aspiring method in biomedicine (Angle et al. 2016) as well as in invasive species (Fukuhara et al. 2010) and wildlife monitoring (Dahlgren et al. 2012). Dogs have an enormous ability to detect and differentiate scent and previous studies focusing on wildlife monitoring showed that the use of detection dogs is more efficient and less invasive than traditional methods (Grimm-Seyfarth et al. 2021). Bats, with declining populations and being at risk through new emerging diseases and anthropogenic effects such as habitat fragmentation and insect declines should not be further stressed by survey methods. However, in order to protect bats over long term, knowledge on their habitat is essential. But currently, our knowledge about roost habitat and hibernacula - especially for species that don't use building structures as roosts - is very limited compared to e.g. feeding habitat.

In addition, a lot of bat tree roost surveys currently rely on discoveries by chance, e.g. exit counts at trees which can be very time consuming and inaccurrate, or on approaches focusing on single individuals such as telemetry. First international studies, reports and case studies have shown that using detection dogs in bat surveys could enrich the available "methodology catalogue" under certain conditions (Chambers et al. 2015, Underwood 2021, Michaelsen et al. 2012, Kelly 2014).

Use of dogs in bat surveys

A well-known area to use detection dogs is the search for carcasses underneath wind turbines in order to determine fatalities of bats and birds in different degradation stages in a defined radius around the power plant. To our knowledge all available studies found a better performance of professional trained detection dogs looking for carcasses of bats and birds compared to human observers (e.g. Smallwood et al. 2020, Domínguez del Valle et al. 2020, Mathews et al. 2013, Bennett 2015). Therefore, this method should be seen as the "gold standard" to track such fatalities under wind turbines, with the prerequisite that only suited (e.g. motivated to "work") and professionally trained dogs are used.

The use of detection dogs when it comes to locating bat roosts (summer or winter) in urban, cave or forest habitat is less explored and only few case studies/reports and scientific articles are available with different outcomes (e.g. Chambers et al. 2015, Underwood 2021, Michaelsen et al. 2012, Kelly 2014.). Nevertheless, the method is already used operationally in the field more and more also in Europe, sometimes with dubious results, outcomes, approaches and training

techniques by practitioners that are not specialists in detection dog training and/or bat ecology.
The task of the detection dog in this case is to locate the roost (tree or building) or hibernacula site in a predefined area as close as possible by indicating on the respective building, tree or cave. In contrast to the carcass search the dog needs to detect a scent target/odour pool (depending on environmental condition) several meter above the ground. Additionally in most cases, the dog handler cannot confirm a dogs' correct indication immediately in the field, which puts an additional challenge to the training of these dogs.

The only research article available on this topic by Chambers et al. 2015 investigating the detection of tree roosts, showed that dogs (N=2) found 60 % of artificially brought out guano in 2 m height and only 20 % at 6 m height. Dogs only detected 29% of natural roosts at the defined "correct" distance of less than five meters to the tree. The authors argue that the dogs sometimes only reacted to the scent at a larger distance to the tree and therefore they would consider redefining the "correct" distance for bat roost detection dogs in favour of a larger distance. Environmental conditions such as temperature and height of roosts influenced the detection of roosts. Dogs were better at finding roosts at warmer temperature, in lower height and when more individuals used the roost (Figure 1, copied from Chambers et al. 2015). The authors conclude that dogs could be an additional method to define forest areas that should be under protection and that other methods should be used to verify the roost (e.g. exit count) and predefine the area where a dog should search (acoustic monitoring). The limitations of this study are mainly the sample size of only two dogs (number of roosts 17) and its' specific ecogeographic conclusions for the US, which cannot all be taken for granted for Europe.

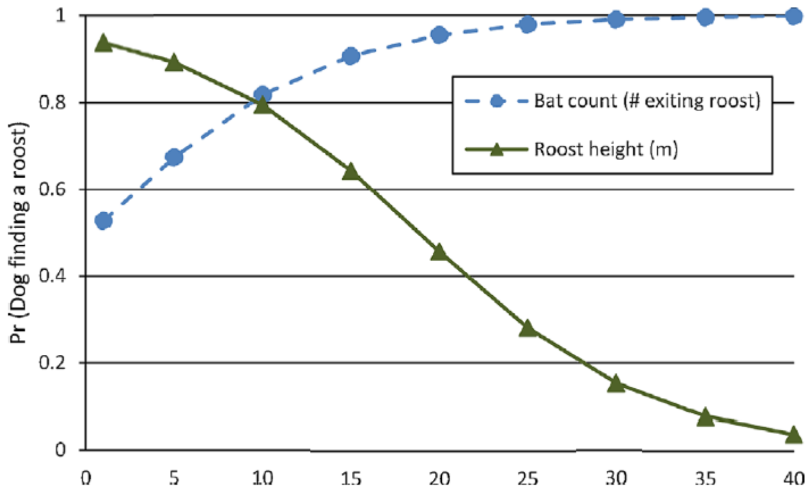


Figure 1: from Chambers et al 2015: Figure showing a model derived from their findings describing the detection probability of a bat roost depending of the height of the roost and number of animals using the roost.

Another study tested one single young dog on bat guano detection in artificially brought out bat boxes, cardboard boxes and directly at the tree (*Soprano pipistrelles* and controls) up to 2.2 m. Single tests looked at different heights of detection (max. 6m) and naturally used bat boxes (N=2). They found that the dog detected all (n not specified) artificially brought out samples up to a height of 4.5m (Michaelsen et al. 2012). The two bat boxes could be located by the dog. However, the methodology of this test is poorly described, thus it is not clear, whether the dog was tested double blind (no person present knew where the guano was located), which can heavily affect the performance of the dog ("Clever Hans effect". Lit et al. 2011). Additionally, it is unclear, if the dog was tested with unknown samples or with those that were used in the training (N=2 boxes), as odor of populations can differ and dogs can learn the odor of specific samples but not generally alert on unknown samples when they did not have the chance to generalize the odour. Therefore, we can only conclude that this dog was able to detect the specific samples it was trained on in a specific height but not necessarily the specific species in different contexts. Also, this study did not test the detection of natural roost in trees, which seemed to be much more difficult for the dogs in Chambers et al. study compared to the artificially brought out guano. A case report also documented the trial of the organization “conservation canines” to train bast roost detection dogs, however this attempt was described as more difficult than initially thought (Kelly 2014). Another case report is describing the detection of hibernacula sites by one single trained detection dog (Underwood 2021) in Alaska. Here the aim was that the dog is indicating on former used sites by bats - so even alerting on the scent-trace of an individual bat formerly present in a specific spot. This performance seems very impressive (camera traps showed that bats would land on the exact spot where the dog was indicating), but also involved extensive training. However, it still remains to be tested in a formal setting and under several real-world conditions, ideally with several dogs. Moreover, it must be noted that the cave sites investigated during these trials are often at “dog level” in terms of height, otherwise such exact pinpointing would not have been possible. The detection of tree roost is a completely different scenario. Besides these published studies only case reports, anecdotes and operational reports exist which describe the use of bat roost detection dogs for buildings or trees (e.g. Deutsche Bahn, Universität Freiburg im Breisgau, Naturschutzhunde Österreich, planning offices to mention some of many). Currently, all these dogs are not tested in a standardized way, regarding their performance (side note: Naturschutzhunde Österreich carried out a certification for artificially put out guano samples recently).

To sum up these results, the performance of bat roost detection dogs – first of all for natural roosts - remains open and unvalidated. More studies are needed to investigate the efficiency and practicability of the use of bat roost detection dogs (summer and winter) looking into the method in a broader sense. Though Chambers investigated the method to quite some detail, a bigger sample size regarding tested dogs and later checking different type of roosts (winter/summer/mating) is needed. Also looking into different habitats than the US is helpful, in order to be able to generalize the use of such detection dogs.

In order to assess the performance and quality of operational bat roost detection dogs in Europe for bat tree roosts, Artenspürhunde Schweiz made a call for operational teams based in Europe in 2020 to take part in a comparative study investigating the performance of the dogs at artificially brought out samples and natural bat roosts.

Material and Methods

Pilot tests with one dog

Brought out guano

To test the general approach, we tested one dog (trained by Artenspürhunde Schweiz) in 2020 on 10 plots (50 m x 50 m) (Fig. 2), if and how fast it could locate a guano mixture from tree living species attached to a tree in 4 m height (brought out 12-24 h before search was conducted). The test was double blind (no person present knew on which tree the guano was applied).

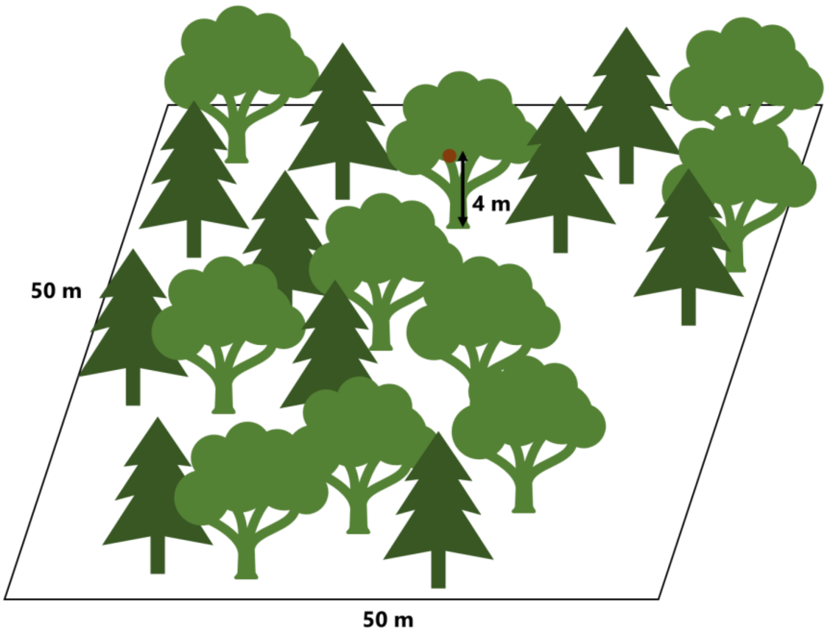


Figure 2: Representation of a test plot 50m x 50m in size with one tree prepared with 2 teaspoons of a guano mixture (mixed with water to get a suitable consistency) attached to the bark of the tree, 12-24h before the dog searched the area.

Natural tree roosts

A total of 20 plots of 50 x 150 m in size each, which were determined by a local planning office (StadtNatur) that conducted a telemetry study in summer 2020 in order to locate more tree roosts , were searched by the dog team. The team knew neither the number of tree roosts, nor which of the areas contained any. The dog handler only received the four GPS coordinates which made up the border of each plot. Using the Swisstopo App(© 2021 Bundesamt für Landestopografie swisstopo) the coverage of the search area could be checked during the search by the dog handler. The dog also carried a GPS device during the search in order to validate area coverage. Each area was systematically searched by the dog team according to environmental conditions (vegetation, slope, weather). The dog was guided through the search area on a tow lead and a search harness - equipped with a small bell. On average, two areas were searched per day. Before the search, the temperature, humidity, weather and wind were documented. No searches were carried out when temperatures were above 20 °C, as the search performance and endurance of detection dogs under such conditions have been shown to decrease significantly. When detecting the scent of bat guano the dog alerted the handler by sitting. The behaviour of the dog was constantly observed by the handler. Clear indications were rewarded using food or play. The dog handler classified the indications according to the dog's behaviour ("certain" to "uncertain" indications). Trees where the dog made a clear/certain indication were marked with blue, degradable forestry marking tape. In addition, the GPS coordinates, the tree species and the qualitative diameter of the tree were documented, and the tree was photographed. The search took place between the end of September and mid-October 2020 on a total of 12 days.

Main study 2021

Test on brought out samples

Artenspürhunde Schweiz organized two tests for dog teams in Switzerland (n=4) and due to travel restrictions during the Corona pandemic in Germany (n=5) with artifically brought out samples. The test conditions were therefore not identical, but the procedure was exactly the same. The test was performed double-blind under standardized conditions. The number of samples and controls per plot was unknown to the teams. The nine dog teams each searched six plots of 50m x 50m each (Fig. 4). Each plot contained two controls (soil samples (2 tsp) at a height of 4 m), a tree with applied *Myotis daubentonii* guano (2 tsp, 4 m high) and a tree with applied guano of *Nyctalus noctula* (2 tsp , 4 m height) (Fig. 3,4). The trees containing control or guano samples were chosen randomly within the plot. In addition, each dog team was observed at three telemetry-determined natural roost regarding the reaction of the dog at natural roosts (video documented).

Figure 3:

Tree prepared with bat guano (indicated in blue) mixed with water for better consistency. The spot with guano should "imitate" a opening of a roosts where the scent can spread from.

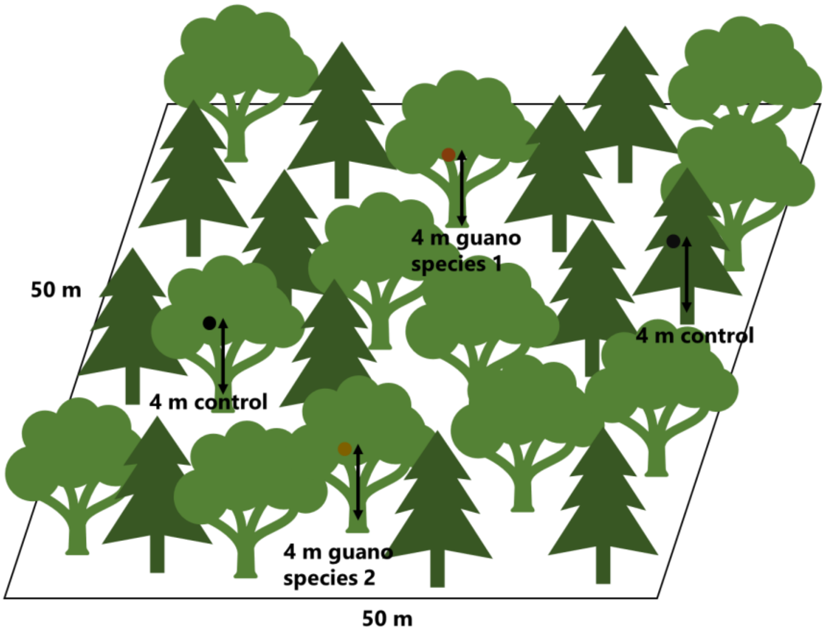


Figure 4: Representation of atest plot including 2 control trees prepared with 2 tsp of soil and 1 tree with *N. noctula* and 1 tree with *M. daubentonii* samples (2 tsp) at 4 m height.

Validation study at natural tree roosts

To test the performance of the dogs at natural roosts a total of 16 plots (50 m x 50 m) were searched by a total of seven dog teams of which 6 were tested on put out guano before as well (Fig. 6, Tab. 1). All plots but one had at least one (max. 2) validated (exit counts summer/autumn 2021) tree roost in a random position within the plot (total number of known natural roosts = 17). The number of roosts (0 – 2) were not known for the participants of the study. All trees within the plot were labelled with livestock markers to ensure 100% correct identification of the trees (Fig.5).

Figure 5: Tree marked with livestock paint for identification in the field.

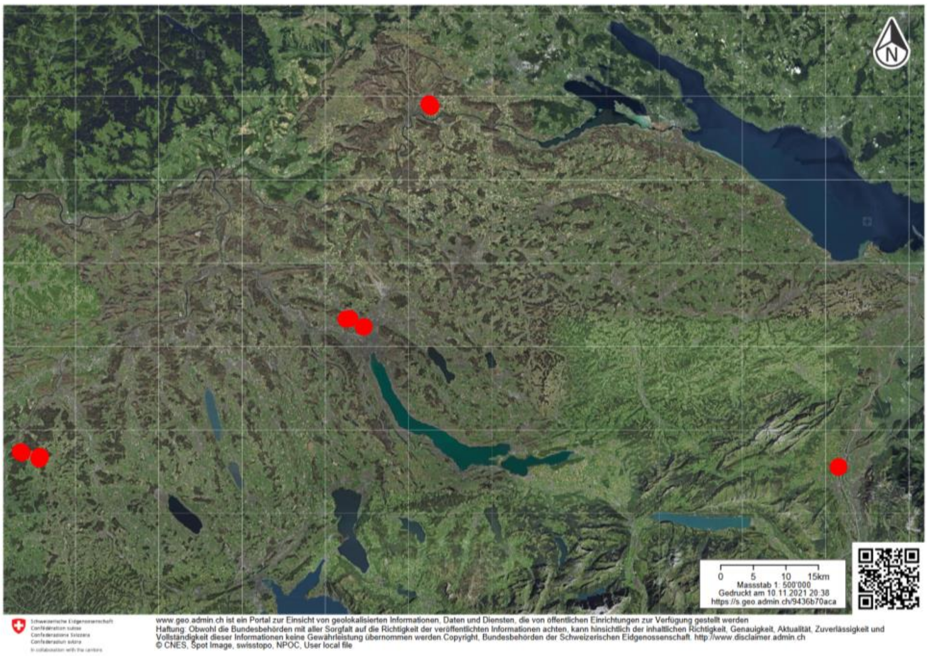


Figure 6: Satellite image of Switzerland showing the locations of the plots where the natural tree roost study was conducted.

Table 1: Overview of plots searched for natural roosts. In total 17 roosts were available within 16 different plots.

Location	Species	Number of known roosts
Schaffhausen	*Myotis daubentonii*	1
Schaffhausen	*Myotis daubentonii*	1
Schaffhausen	*Myotis daubentonii*	1
Pfaffnau	*Nyctalus noctula*	1
Pfaffnau	*Nyctalus noctula*	1
Pfaffnau	*Nyctalus noctula*	1
Pfaffnau	*Nyctalus noctula*	1
Pfaffnau	*Nyctalus noctula*	0
Roggwil	*Nyctalus noctula*	1
Roggwil	*Nyctalus noctula*	1
Zurich	*Nyctalus noctula*	1
Zurich	*Nyctalus noctula*	1
Zurich	*Nyctalus noctula*	2
Zurich	*Nyctalus noctula*	2
Buchs	*Nyctalus noctula*	1
Buchs	*Nyctalus noctula*	1

A single plot was searched by only one participant per day. The search was conducted double blind. Dog handlers carried a GPS and finds were documented by pictures of the tree, GPS location of the tree, tree number and further environmental variables. The nearest distance from the location of an indication to the known tree roost was determined after completing the search of the whole plot.

Validation of additional indications at unvalidated trees

In order to validate additional findings of the dogs, where we do not know whether there is a natural roost, we sent tree climbers to a selection of those trees and evaluated the trees for known use in previous years and structures that would be suitable for a bat to roost.

Marking of trees

Trees that could be validated to be used by bats were/will be marked with blue paint in consultation with the forestry service, so that these trees can be protected in the long term.

Questionnaire for participating dog handlers

After the search was completed, we distributed a questionnaire to all participating dog handlers in order to rate the performance of their own dogs, report difficulties they had during the searches and assess the general suitability of the method.

Preliminary results

Pilot tests

Brought out guano

The trained dog detected 9 out of 10 brought out samples at 0-1 m distance to the respective tree. The team needed 7.7 +- 1.09 minutes to locate the tree starting the plot in a position that seemed ideal to the dog handler (e.g. taking into account wind direction).

Natural tree roosts

Seven of the twenty plots contained tree roosts previously determined by telemetry (*Nyctalus noctula*). The dog indicated between 2 and 24 times per plot (total number of indications = 235).

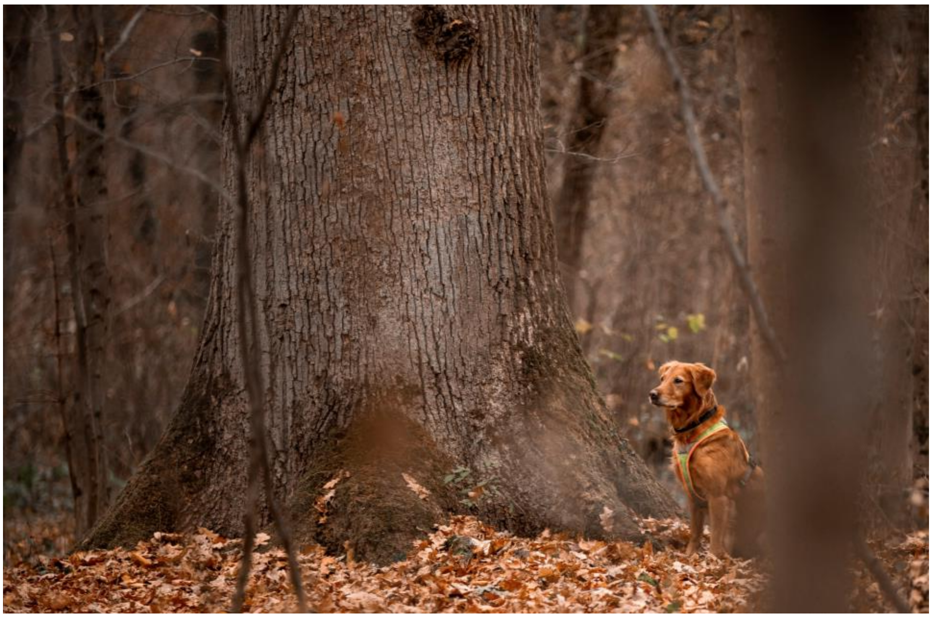


Figure 7: Detection dog indicating in front of a tree with a tree roost.

Figure 8: Detection dog searching a plot for tree roosts.

On average, this resulted in 11.35 +- 5.89 finds per 50 x 150 m area. The search time per area (time required for the documentation of the finds excluded) varied from 22 to 47 minutes, which corresponds to an average time of 32.52 +-

5.62 minutes. The indications varied greatly in terms of direct pointing at a tree and certainty of the dog's behaviour. 211 indications were certain and specific, 7 were certain but rather indicating an area, and 17 indications were rather uncertain. The dog indicated manly on deciduous trees (beech, oak, linden, ash, hazel, cherry, apple, elm, alder, hornbeam, poplar), but partly also on conifers (red spruce, pine, larch).

The data of the pilot study will be evaluated in more detail including the distances from the telemetry trees to those where the dog indicated.

Main study 2021

Brought out guano

This data is still being analysed, but preliminary results show the following pattern outlined in Table 2. Unfortunately, we could not use the GPS data collected, as due to poor satellite connectivity in the forest, the GPS variation was too big and accuracy therefore too small. Therefore, data validation only relied on validation at site, which produced some NA in the table that are still being analysed.

Table 2: Detection of brought out samples by the different dog teams

	Correct tree (total of 12 correct trees)			**Control**	**Additional finds**
Dog team	**0-1m**	**1-5m**	**5-15 m**		
1	2	NA	2	NA	3
2	1	NA	1	NA	16
3	3	NA	NA	NA	15
4	4	0	3	1	No
5	2	0	4	1	No
6	2	NA	NA	NA	13
7	5	2	2	0	No
8	6	0	0	0	No
9*	10	1	1	0	Several

*double blind but knew general set-up of the study

Validation study at natural tree roosts

Table 3 is showing all correct indications at known natural tree roosts. Dogs did differ a lot in their success of finding tree roosts (22-94% detection rate). Many additional finds by the dogs are under current validation for roosts present.

Table 3: Indications at correct trees and the respective distance of indication

Correct tree (total of 17 known natural tree roosts)				
Dog team	**0-1m**	**1-5m**	**5-15 m**	**N and % found**
1	6	1	7	14 (78%)
2	2	0	2	4 (22%)
3	14	1	2	17 (94%)
4	5	2	5	12 (67%)
5	5	1	3	9 (50%)
6 (4 NAs in data)	3	1	3	7 (39%)
7*	15	0	2	17 (94%)

*set up known for dog handler, but double blind; bold numbers mark dog handlers that are part of Artenspürhunde Schweiz (known training methods)

Validation of additional finds

Several of the additional indications turned out to be trees that were used by bats in previous years. Three trees in total could be validated so far to be used by bats (exit count, guano remains). More validations are in progress.

Questionnaire

Overall, the questionnaire showed that the handlers see great potential in the use of bat roost detection dogs. Especially when used together with bat detectors and exit counts. However, one prerequisite of this is that the dog handlers know enough about the biology of bats and can read their dog very well. Moreover, the dog needs to be an experienced, high driven, detection dog in a good body shape and willing to work in harsh conditions (brambles, thiket etc.). The team should be tested on a regular basis at natural roosts and put out samples to make sure they search at a high enough quality to be operational in the field. Additionally, several factors should be considered which can influence a dog's search success (Figure 9, Figure 10).

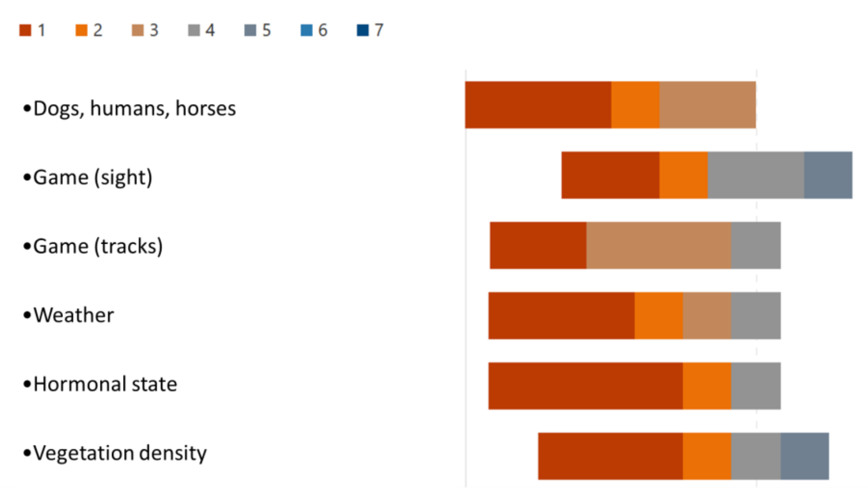


Figure 9: Degree to which specific factors influenced/disturbed a dogs' search for natural roosts (1: no influence up to 7: a lot of influence).

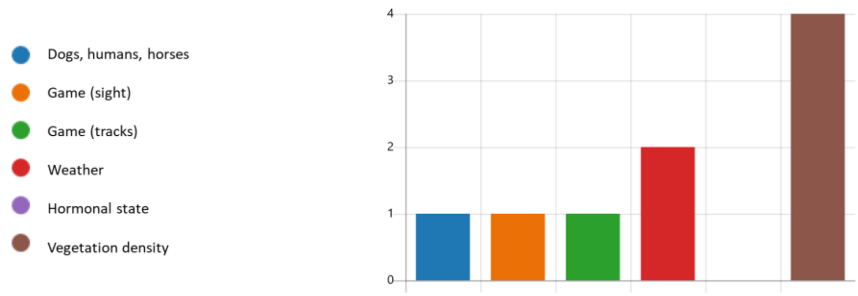


Figure 10: Factors that influenced the search performance of the dogs during the search at natural roosts (Number of dogs affected).

Discussion of preliminary results

The study showed a big variance in accuracy and success rate when it comes to the detection of bat guano, be it artificially put out or natural roosts. Furthermore, many additional finds occurred. Only a small amount of the additional trees that have been alerted on by the dogs were assessed by exit counts, tree climbers or bat experts. A small fraction of these evaluated trees was categorized as bat roost trees. Since the detection dogs are conditioned on the scent of guano but not on live animals, they are not only indicating on currently used roosts, but also those that have been used in the past but are currently unoccupied. This also means that not all finds can be revalidated. Since the training possibilities at known natural roosts are in general very limited (since often only a few roosts are known), it is not possible to determine what exactly the dogs alert on (amount and age of guano). It is possible that the dogs also alerted on guano which was dropped by bats while hunting. In addition, it is unknown how long old roosts (not used for several years) are still “smelly” and thus alerted on by the dogs. Another negative point is that due to the large number of indications that occurred, errors in the execution of the indication behaviour can also creep in. This was also observed by Chambers et al. in the US, so it seems to be a general pattern for tree root searches, as these bat species have a high turnover in using different roosts (small scent picture for a roost that is only used for one night for example). Therefore, in our experience bat roost detection dogs should continuously be trained (before and during operational periods) at known roosts to fine tune the indication behaviour. Also, our suggestion would be to always let several dogs search the same plots to verify the indications. Overall, we also recommend to only train experienced and not naïve young detection dogs (not as first target scent) for bat roost detection, as the training seems to be one of the most challenging within the wildlife detection dog field. A lot of trust between the dog handler and dog is needed to perform this search at a high quality level. Also, one has to consider that training, with 3D structures and often several bat species (generalisation needed) involved – will take even with an experienced dog in our experience up to 2 years. However, when correctly conducted the results can be quite satisfactory (67-94% detection rate for teams trained by Artenspürhunde Schweiz, see results section).

Figure 11: Detection dog team from Artenspürhunde Schweiz during the documentation of an indication.

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