Supplementary Presentation 1

Field protocol for experimental human approach trials on wild, GPS-collared wolves

Eriksen A, Versluijs E, Fuchs B, Zimmermann B, Wabakken P, Ordiz A, Sunde P, Wikenros C, Sand H, Gillich B, Michler F, Nordli K, Carricondo-Sanchez D, Gorini L and Rieger S (2022). A Standardized Method for Experimental Human Approach Trials on Wild Wolves. Front. Ecol. Evol. 10:793307. doi: 10.3389/fevo.2022.793307

1 Introduction

This field protocol has been developed as a standardized tool for testing the response of GPS-collared wild wolves when approached by human observers in the field. Following this protocol will give the following data:

- High-frequency GPS positions from the wolf collar for the period before, during and after the approach trial.
- A GPS track log from the approaching observer(s).
- Observational data collected in the field during and after the approach trial, using a standardized field form (Suplementary Presentation 2).

A tutorial for visualization and variable extraction from the GPS data from this protocol using the R programming environment can be found in Supplementary Presentation 3. The manual describes the calculation of observer-wolf distances and extraction of the time and location for flight initiation and resettling of the wolf, from which several other variables can be calculated (flight speed, straightness, duration and displacement).

2 Collar requirements

The protocol was developed and tested on wolves equipped with Vectronic VERTEX Plus collars, but can be conducted using any GPS collar with the following functions:

- GPS positioning frequency programmable down to 1-minute intervals
- Two-way wireless radio or satellite communication (e.g. GSM or Iridium), enabling:
    - remote re-programming of positioning schedule, and
    - data transmission after a set number of acquired positions

3 Collar scheduling

To avoid habituation, allow at least 14 days between consecutive approach trials on the same individual/pack/pair. Longer breaks between trials can be considered in areas with low human presence. For family groups, avoid disturbance during the denning and early pup rearing period. Approach trials should be scheduled for the time of day with the lowest expected wolf activity based on inspection of previous GPS positions. This protocol illustrates a trial starting in the middle of the day.

GPS collar scheduling for the day of an approach trial:

- Preparation period:
  - 10-minute positioning interval for a period of four hours.
  - E.g. 08:00-12:00 local time (09:00-13:00 during daylight saving time DST).
- Approach period:
  - 1-minute positioning interval for a period of two hours following the preparation period.
  - E.g. 12:00-14:00 local time (13:00-15:00 DST).
- Post-disturbance period:
  - Ten-minute positioning interval for a period of three hours following the approach period.
  - E.g. 14:00-17:00 local time (15:00-18:00 DST).

4 Observer type

The protocol has been tested with the following two observer types:

- Single hiker: no talking, but no effort to be quiet
- Pair of hikers: casual conversation, no effort to be quiet

Other variants can be added, such as observer jogging, skiing or with dog on a leash

5 Approach procedure

The spatial arrangement of the approach trial is illustrated in Fig. 1, and abbreviations and specifications of the terms are explained in Table 1.

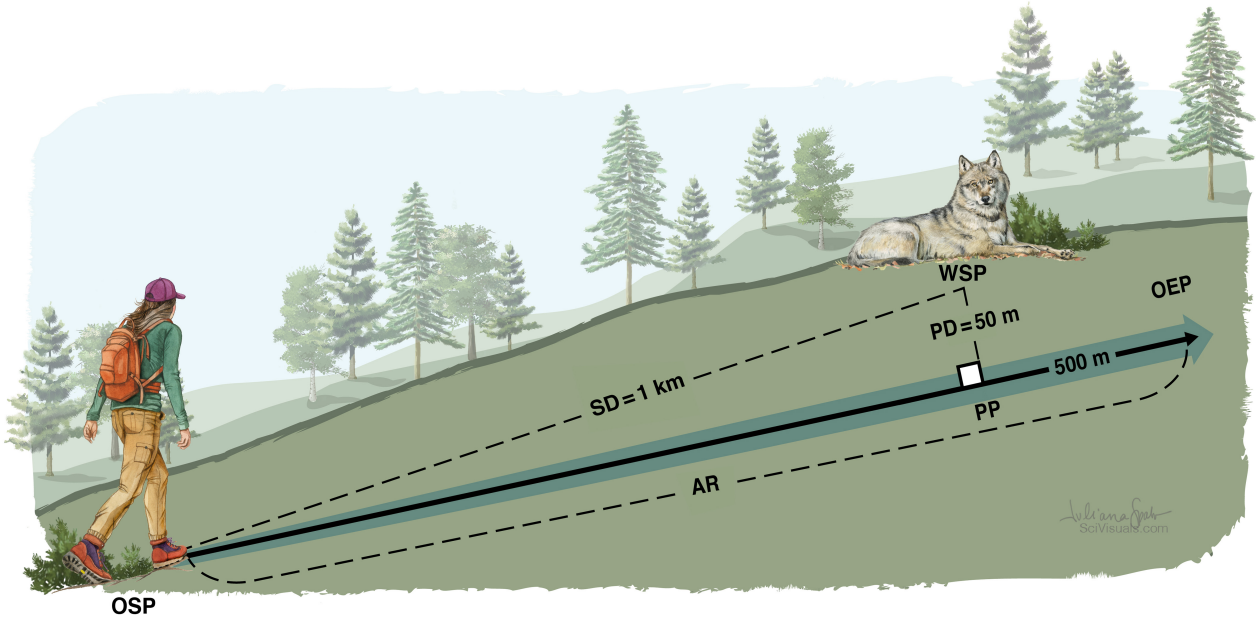

Figure 1. Illustration of the spatial arrangement of a standardized experimental human approach trial on wild wolves. Abbreviations are explained in Table 1. Note that the graphic is not drawn to scale.

Table 1. Abbreviations and descriptions of terms used in the field protocol for experimental human approach trials on wild wolves. Spatial arrangement is illustrated in Fig. 1.

Abbr.	Name	Description
WSP*	Wolf starting position	Wolf position at the beginning of the trial.
AR*	Approach route	Straight-line transect walked by observer. OSP ➜ PP ➜ OEP. AR should be accessible on foot, with no ridges between AR and WSP.
OSP	Observer starting position	Starting point of AR. Should be accessible without disturbing the wolf prior to the trial, and at a defined minimum distance (SD) from WSP.
SD*	Starting distance	Distance between OSP and WSP. SD should ideally be ≥ 1 km. but in areas with high density of human infrastructure around WSP, SD down to 500 m can be used.
PP*	Passing position	Point along AR with the shortest distance (PD) to WSP. WSP-PP should be perpendicular to AR.
PD*	Passing distance	Distance between WSP and PP. PD should be as close as possible to 50 m.
OEP*	Observer end position	Endpoint for AR, 500 m past PP.

* Initially set during the preparation period based on the best available information, and later corrected based on wolf collar data and track log from observers' handheld GPS.

5.1 Preparation period

Use the preparation period to determine the wolf's location from the received 10-minute GPS fixes and consider possible approach routes (AR). It is recommended to wait for the first batch of 1-minute positions before determining the final AR and starting the trial.

Based on the most recent wolf position, and using the criteria specified in Table 1, AR can be generated using the following steps:

1. Plot the wolf start position (WSP) on a map.
2. Centered on WSP, plot a circle with a 1 km radius.
3. Choose a suitable observer start position (OSP) on or outside this circle.
4. Centered on WSP, plot a circle with a 50 m radius.
5. Plot a straight line (AR) from OSP that is tangent to the 50 m circle and continues for another 500 m.
6. The tangent point between the line and the 50 m circle is the passing position (PP).
7. The end point of the line is the observer end position (OEP).

5.2 Approach period

Use the field data form (Supplementary Presentation 2) to register field data during the approach trial. Start the approach trial when 1-minute positioning has started and AR has been determined:

1. At OSP, initiate track log with a handheld GPS unit. Logging one position per second is recommended to facilitate matching with simultaneous wolf positions.
2. At regular hiking speed, start walking along AR following the standard approach protocol (Fig. 2A), passing PP no later than 15 minutes before the end of the 1-minute positioning (13:45, or 14:45 during DST), until reaching OEP.
3. At any time during the trial, switch to the direct encounter protocol (Fig. 2B) only in cases of visual wolf observation meeting all the direct encounter criteria specified below.
4. From OEP, return to vehicle in an arch away from the last known wolf position, avoiding further disturbance of the wolf.
5. When back at vehicle, end and save the track log on the handheld GPS.

5.3 In the case of a direct human-wolf encounter

The flow chart in Fig. 2 illustrates the standard protocol as described above (Fig. 2A) as well as a modified protocol in cases of a direct human-wolf encounter during the approach trial (Fig. 2B). The observer should switch from standard protocol to direct encounter protocol if and only if all of the following criteria are met:

1. Visual observation of wolf ahead of the observer when observer is facing OEP
2. The observer would notice the wolf in a non-trial situation
3. Wolf is aware of the observer
4. Wolf does not leave immediately

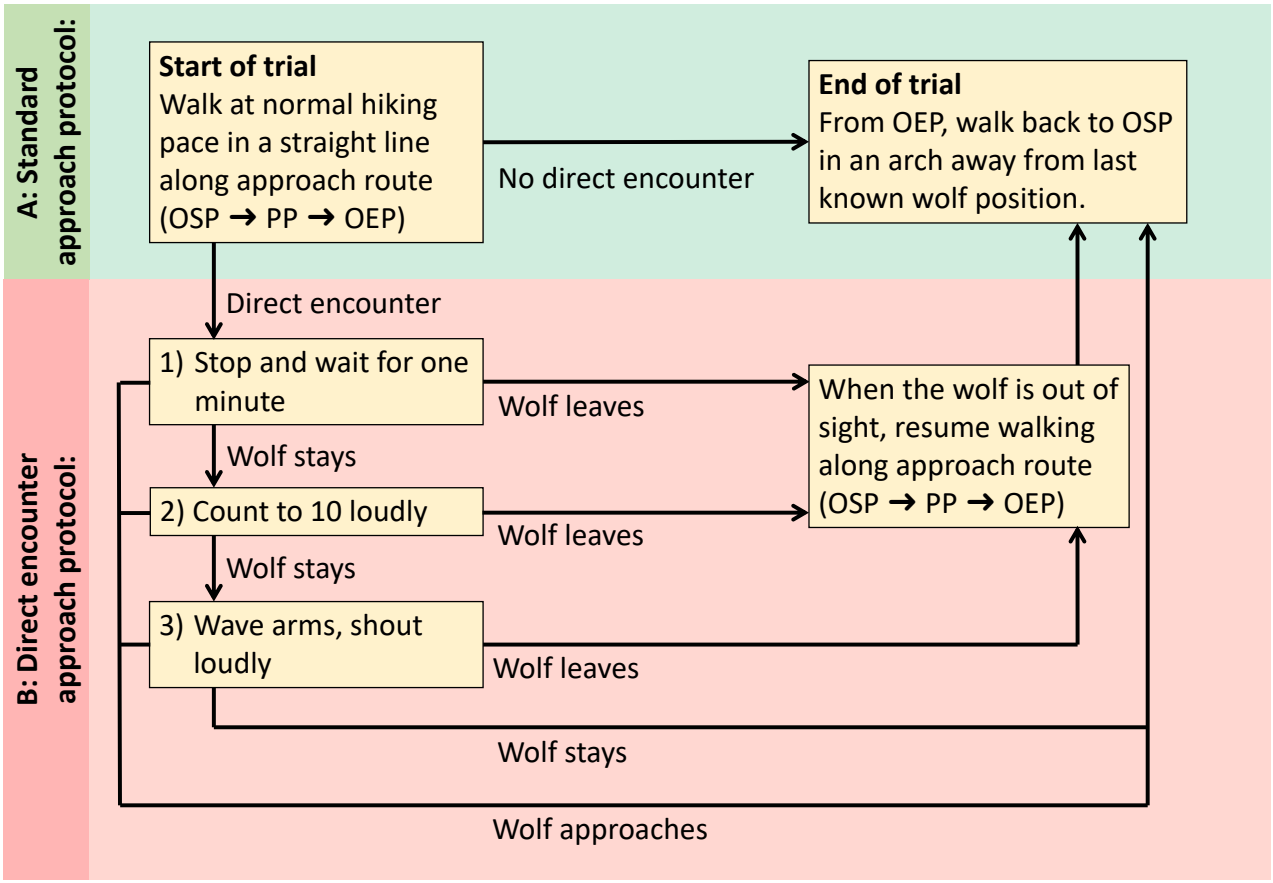

Figure 2. Schematic protocol for experimental human approach trials on wild, GPS-collared wolves. Observer will switch from standard protocol (A) to direct encounter protocol (B) if all the following criteria are met: Visual observation ahead of the observer, wolf is aware of observer, observer would notice the wolf in a non-trial situation, and wolf does not leave immediately.

6 Post-trial data sampling

6.1 Visibility measurements

After the trial has ended, identify the positions of flight initiation and resettling using the procedures given in the data analysis protocol (Supplementary Presentation 3) and/or by visual inspection of the GPS data. In the field, measure the visibility at these two locations after the wolf has moved at least 1 km away from both the flight initiation and resettling positions. The visibility measurements should follow the description by Ordiz et al. (2009), using a brightly colored cylinder (60 cm tall and 30 cm diameter). Place the cylinder at the coordinate of flight initiation/resettling. In the four cardinal directions, measure the maximum distance at which the cylinder can be seen.

6 Customization of the protocol

Some elements of the protocol are customizable to weigh the likelihood of a successful trial against collar battery usage, whereas other elements should be kept constant to ensure data quality and comparability across studies. Options and recommendations for optimizing the protocol are described below and summarized in Table 2.

Table 2. Recommendations for optimization and customization of the field protocol

Factor		Default	Options and recommendations	Possible implications
Time of day		Middle of day	Inspect GPS data from individual wolves prior to first trial. Recommended to deviate from default and schedule for least active period if the wolf shows consistently high activity during the day.	Consider variation in the time of day of the trials when interpreting the results.
Starting distance		≥ 1 km	Can be reduced in areas of high human impact (e.g. high road density, small patch size), but never < 500 m.	Wolf disturbed immediately, no meaningful FID
Passing distance		50 m	Not customizable	
Data transmission freq.		1 / 7 pos.	Customizable (+/-) Can be increased if accessibility or communication coverage is low and/or territories are large to increase likelihood of receiving updated positions and reaching start position in time. Can be reduced if accessibility and communication coverage are good and/or territories are small.	+: Increased battery usage, more frequent updates -: Reduced battery usage, less frequent updates, increased risk of unsuccessful trial
Preparation period	Duration	4 hours		
	Positioning freq.	1 pos. / 10 min		
Approach period	Duration	2 hours	Customizable (+/-) Keep sufficient to reach passing position at least 15 min before the end of the approach period to ensure	+: Increased battery usage, more time to conduct trial -: Reduced battery usage, less time to conduct trial
	Positioning freq.	1 pos. / min	Can be reduced to a minimum of 1 pos. / 3 min. to increase collar battery life, but keeping default frequency is highly recommended for maximum precision and comparability with other studies.	-: Reduced battery usage, reduced precision and comparability
Post-disturbance period	Duration	3 hours	Customizable (+/-) Keep sufficient to include the entire flight period as defined in the instruction manual for data analyses (Supplementary Presentation 3)	+: Increased battery usage, more time to detect resettling. -: Reduced battery usage, less time to detect resettling
	Positioning freq.	1 pos. / 10 min	Can be reduced to 1 pos. / 20 min. to increase collar battery life, but keeping default frequency is highly recommended for maximum precision and comparability.	-: Reduced battery usage, reduced precision and comparability

Frequent GPS positioning during the preparation period gives information about the location of the wolf to increase the chances of a successful trial. The exact duration and positioning frequency of the preparation period can be adjusted to suit each project. During the approach period, 1-minute positioning interval allows for precise definition of flight initiation and high temporal resolution of the initial flight path. For the post-disturbance period, 10-minute positioning is used to monitor post-disturbance movement and identify resettling. Lower positioning frequency during the approach and post-disturbance periods can be used to increase collar battery life. However, due to a reduction in both the precision of flight initiation and the resolution of the flight path, results for e.g. flight initiation distance, flight speed or straightness will not be directly comparable to studies using the higher positioning frequencies suggested in this protocol. For comparisons of results using different positioning frequencies, see the main paper. For comparative studies, all data will have to be down-sampled to match the dataset with the lowest resolution. The duration of the post-disturbance positioning is set to three hours in this protocol, but most importantly, it should be long enough to include the entire flight period as defined in the instruction manual for data analyses (Supplementary Presentation 3).

Remote transmission of a new schedule *to* the GPS collar is possible during the transmission of data *from* the collar, and hence the baseline positioning frequency and the number of positions per data transmission will affect how long before the trial the approach schedule needs to be sent to the collar. Data transmission from the collar is energy demanding, and may sometimes take more than one minute and thus obstruct the acquisition of a new GPS fix at 1-minute positioning frequency. We used data transmission in packages of seven positions, but the data transmission frequency should aim to balance battery consumption, frequent updates of the wolf location, and the potential for missing GPS fixes.

8 References

Ordiz, A., O.-G. Støen, L. G. Langebro, S. Brunberg, and J. E. Swenson. 2009. A practical method for measuring horizontal cover. Ursus **20**:109-113.