DAMA GAZELLE SURVEY

THE MANGA REGION WESTERN CHAD

FEBRUARY 2015

By:

Tim Wacher, Darren Potgieter,

Mahamat Hassan, Satangar Dogringar,

Thomas Rabeil

CITATION: Wacher, T., Potgieter, D., Hassan, M., Dogringar, S., Rabeil, T. 2015. *Dama gazelle survey. The Manga region, Western Chad, February 2015.* Zoological Society of London, African Parks Network and Sahara Conservation Fund. iii + 27 pp.

AUTHORS:

Tim Wacher (Zoological Society of London)
Darren Potgieter (African Parks Network)
Mahamat Hassan Hatcha (DCBPNC)
Satangar Dogringar (African Parks Network)
Thomas Rabeil (Sahara Conservation Fund)

SPONSORS and PARTNERS

Funding and support for the work described in this report was provided by a grant from US Fish & Wildlife Service administer by Conservation Force and International Foundation for Conservation of Wildlife, with contributions from African Parks Network (Zakouma) and the Sahara Conservation Fund. The field teams comprised staff from the Direction de la Conservation de la Biodiversité, des Parcs Nationaux et de la Chasse, Ministère de l'Agriculture et de l'Environnement, ZSL, APN and SCF.

ACKNOWLEGEMENTS

We thank the Governor of Kanem district at Mao and his officials for assistance, hospitality and support and Irene del Rio of the World Food Programme / Programme d'Alimentation Mondiale (WFP/PAM) station in Mao. Thanks also to Phillipe Chardonnet, Executive Director at IGF, for collaboration and support in organizing funds and to Helen Senn and David Mallon for helpful comments on the original manuscript.

Air Survey team
Darren Potgieter – Pilot (APN)
Tim Wacher – Recorder (ZSL)
Satangar Dogringar – observer (APN)
Mahamat Hassan Hatcha – observer (DCBPNC))

Ground survey Team
Thomas Rabeil (SCF)
Ahamat Hassane (DCBPNC)
Rocco Rava (SVS)
Paul Benecke (APN)

Logistics: African Parks Network managed logistics and fuel for the air survey. Rocco Ravà and his team from Société de Voyages Sahariens (SVS) managed the ground survey.

CONTENTS

ACRONYMS

APN	African Parks Network
DCBPNC	Direction de la Conservation de la Biodiversité, des Parcs Nationaux et de la Chasse
EU	European Union
IGF	International Foundation for the Conservation of Wildlife
MAE	Ministère de l'Agriculture et de l'Environnement
NGO	Non-governmental organisation
O.	Ouadi ('wadi' in English)
OROAGR	Ouadi Rimé–Ouadi Achim Game Reserve
PAM	Programme Alimentaire Mondiale – World Food Program.
RFOROA	Réserve de Faune de l'Ouadi Rimé-Ouadi Achim
SCF	Sahara Conservation Fund
SSIG	Sahelo-Saharan Interest Group
SVS	*Société de Voyages Sahariens*
TLU	Tropical livestock units
ZSL	Zoological Society of London

SUMMARY

This report summarises results of a combined aerial and ground survey of dama gazelle habitats in the Manga region (Kanem) of western Chad.

The survey was funded through Conservation Force with input from African Parks Network and Sahara Conservation Fund. It was carried out by a combined team from Direction de la Conservation de la Biodiversité, des Parcs Nationaux et de la Chasse (DCBPNC), Chad, Africa Parks Network (Zakouma), Sahara Conservation Fund and the Zoological Society of London.

The survey was undertaken to establish whether the largest known area of occupancy in which dama gazelle (IUCN Critically Endangered) have been found in recent years corresponded to a significant population.

The aerial team used standard aerial strip count methodology to record wildlife and livestock in just under 6% of a 12800km^2 survey zone, augmented by extensive free searching of zones where dama signs were reported. The ground team used SCF's standard reconnaissance and line transect methods. Regular coordination between the two teams through satellite phone, enabled exchange of information on dama location and well sites.

Only four dama were found in two groups, both at the northern limit of suitable habitat in areas least frequented by livestock. Two adult females, one 6-12 month calf and one adult male were observed. No sightings were made where additional fresh tracks were observed by the ground team in the extreme east of the survey zone.

No dama were found in the Manga habitat, where 17 animals in several widespread groups were seen in a 2001 ground survey. The groups that were found in the Acacia-Panicum habitat in 2015 were in essentially the same locations as found on the ground in 2014. There was no evidence that a larger population is dispersed through the greater survey zone.

The aerial survey estimate of just under 3000 dorcas in the survey is likely to be an underestimate, since comparison of aerial and ground survey methods indicated potential undercounting bias from the air for dorcas gazelles. There was no evidence of undercounting bias in the estimate of some 30,000 camels in the survey zone.

The survey results are disappointing for dama gazelle, since the only discernible trend across the sequence of surveys in the Manga region, 2001 to date, appears to be downward (from 'very low' to 'extremely low' numbers). The Manga region holds one of only five known remaining sub-populations of dama (RZSS & IUCN 2014), and although it appeared to be the largest in area of extent, may be close to extirpation.

At the same time the exercise has been useful in removing a significant 'unknown' (whether the large area of extent indicated a significant but 'hidden' population that was being missed in slow moving ground surveys) and has clarified options for future conservation of the species in Chad.

Because the Manga area is remote and difficult to access, with no formal protected status, it is recommended that this population does not merit a major conservation initiative at this

stage. But action to increase sensitisation and awareness of the national law on dama & wildlife conservation among all levels of local authority operating around the Manga area should be taken and a flow of information on the status of this remnant group be maintained. An EU supported project being implemented by SCF can provide a mechanism to help achieve this.

But in the light of these results the clear indication from this survey and previous work by SCF, DCBPNC and other partners, is that the dama gazelle is at high risk of extinction in Chad and throughout its remaining range.

Accordingly it is also recommended:

1) That a national strategy for dama conservation in Chad is created.

2) The strategy should include assessment of the option to re-inforce the small population living in the Ouadi Rimé-Ouadi Achim Game Reserve, primarily using captive descendents of dama originally caught in the Ouadi Hawach sector of Ouadi-Rime Ouadi Achim Game Reserve. These are available in zoos, private collections and ranches, particularly in the US and Gulf region. It is noted that the scimitar-horned oryx re-introduction project infrastructure and process currently underway in Chad can provide an excellent framework to achieve this. A detailed review to identify the exact stocks to use for such an effort should be incorporated.

2) The strategy should also ensure that the potential for dama re-introduction to the Ennedi region is assessed in the context of the Ennedi management plan currently being developed by African Parks Network. The existing tourism infrastructure and proposed management plan for Ennedi region offers potential to incorporate and manage such a project for the benefit of the local region, and to provide a second 'pole' of dama conservation within the country, complementing the proposed initiative for dama at OROA.

INTRODUCTION

The dama gazelle is one of four African antelopes currently classified as Critically Endangered by the IUCN Red list system (IUCN 2014). Formerly found from Morocco to central Sudan, a detailed review of the current status of dama indicates that in the last 10 years this striking species has only been recorded in the wild in small numbers in five widely scattered locations (RZSS & IUCN-ASG 2014). The Sahara Conservation Fund and Zoological Society of London have been actively collecting systematic information on the status of these populations in the field. Encounter rates in all five populations are so low that no scientific estimates of population sizes have been obtained. The most intensively monitored population at Termit Massif in Niger, is believed to number no more than 20-50 animals restricted to an area of less than 1000km^2.

The Manga region of western Chad and the adjacent plains to the east of the Manga's fixed dunes is the region in which dama have been found over the largest area in these studies, c. 10,000km^2, Map.1. This has been established by direct observation of animals together with records of tracks and faecal pellets. Faecal pellet identification has been verified by subsequent DNA analysis from samples (Senn et al. 2014).

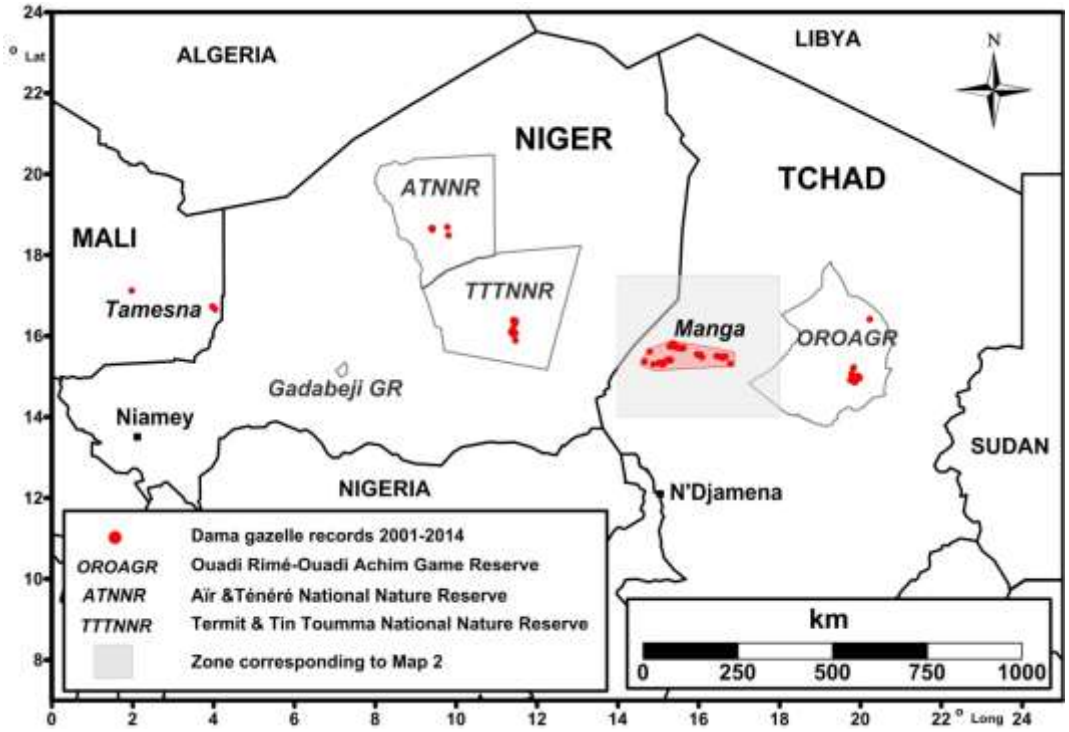
The Manga region is not protected and is widely inhabited by nomads and their livestock (mainly camels and small stock) using a network of wells. Recent social and economic changes have also led to an increased level of trading and transport activity along a major north-south route running between the fixed dunes and the Acacia-Panicum plains. But in general the area is difficult to access and while an open landscape, is slow to travel over on the ground, largely due to the dune slopes, sandy substrate, and numerous small sand hillocks built up against Panicum and other plant tussocks. This has been considered a contributory factor in the persistence of dama there.

In view of the large area over which dama have been recorded in and around the Chadian Manga (5 - 6 x greater than other sites) and the location of the Manga midway between the small dama populations at Termit and Ouadi-Rimé-Ouadi Achim, the region has been identified as a priority site for aerial survey (RZSS & IUCN-ASG 2014). This document reports results of a combined aerial and ground survey conducted in the Manga in February 2015. The survey was achieved through close collaboration between conservation agencies working in Chad (DCBPNC, APN, SCF and ZSL). Core funding was based on a grant administered by the US NGO 'Conservation Force' arising from taxation on desert ungulate ownership in the US, with significant contributions from African Parks Network and Sahara Conservation Fund.

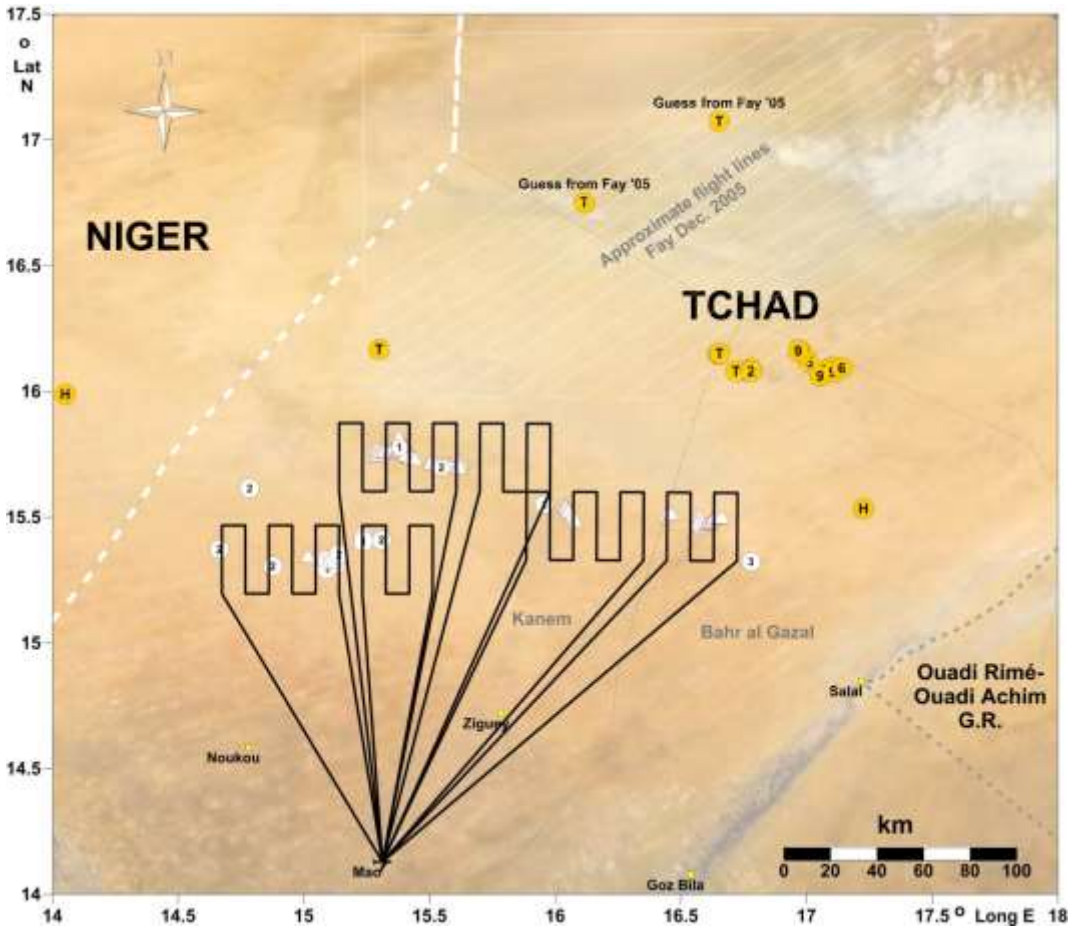
METHODS

The survey was organised into an aerial sample survey using a team comprised of DNPNRFC/APN and ZSL staff, while a simultaneous ground survey was conducted by a team of DCBPNC and SCF staff.

Air Survey: The air survey team was based at Mao town in the administrative district of Kanem, using the 1700m asphalt airstrip, Map 2. The air survey objective was to complete a



Map 1. Distribution of all dama gazelle observations recorded by the Sahara Conservation Fund since 2001, with the relatively large area of extent in the Manga



Map 2. Proposed transect survey routes in relation to all dama gazelle observations (white points) and all addax records (orange points) from the region since 2001.

sample transect survey using a 600m fixed strip width across two principle habitats, the fixed dunes of the Manga and the Acacia-Panicum plains to the east. The survey area was centred on locations where dama had been detected by ground surveys in previous years (Monfort, Newby et al. 2004; Wacher & Newby 2010; Newby, Wacher & Hassan, 2014). The survey zone includes parts of Kanem and Bahr al Gazal districts.

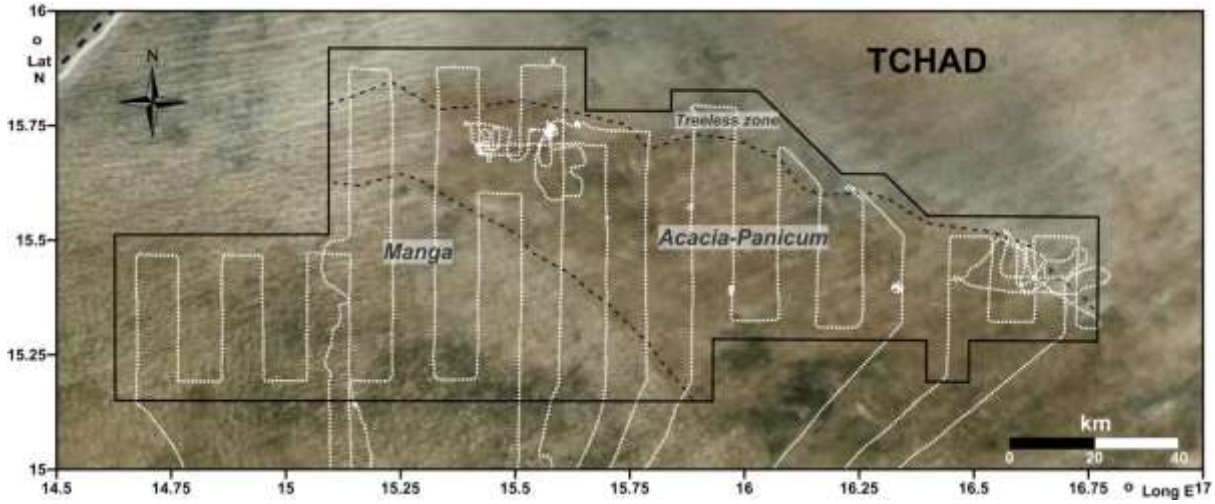
Air survey methods closely followed standard procedures for sample strip counts (Norton-Griffiths 1978). The air survey team consisted of pilot, recorder and two rear seat observers. A four-seat Cessna Skylane 182 operated by African Parks was rigged with metal rods projecting back c. 1m from custom made attachment pods on the wing struts, positioned relative to individual eye height for each rear seat observer to indicate the outer limit of a 300m strip width on the ground when flying at 90m altitude (Norton-Griffiths 1978 & Annex II).

A Garmin GPSMAP 296 was used for navigation, displaying prepared parallel transect routes at 10km intervals, organised into 8 contiguous survey blocks. Planned routes are shown in Map 2 and the realised final survey routes in Map 3. Altitude was managed by laser altimeter aiming for a sustained height of 90m during transect recording. Observers called all observations of wildlife at all times, using the wing strut rods to classify them as inside or outside the sample strip. On transects observers also called all sightings of livestock within the 300m strip, and records were taken of nomad camps and well sightings. The recorder entered all observations into a custom made android GPS data capture application (Wildlife Survey ©Darren Potgieter) on a tablet computer for subsequent download. Two short test flights on 12th February 2015 were used to familiarise the team with observation conditions and methods. The formal transect flying was completed over 6 mornings between 13th to 19th February. In response to information received from the ground team, time was also allocated to free searching for dama gazelles from the air on some days.

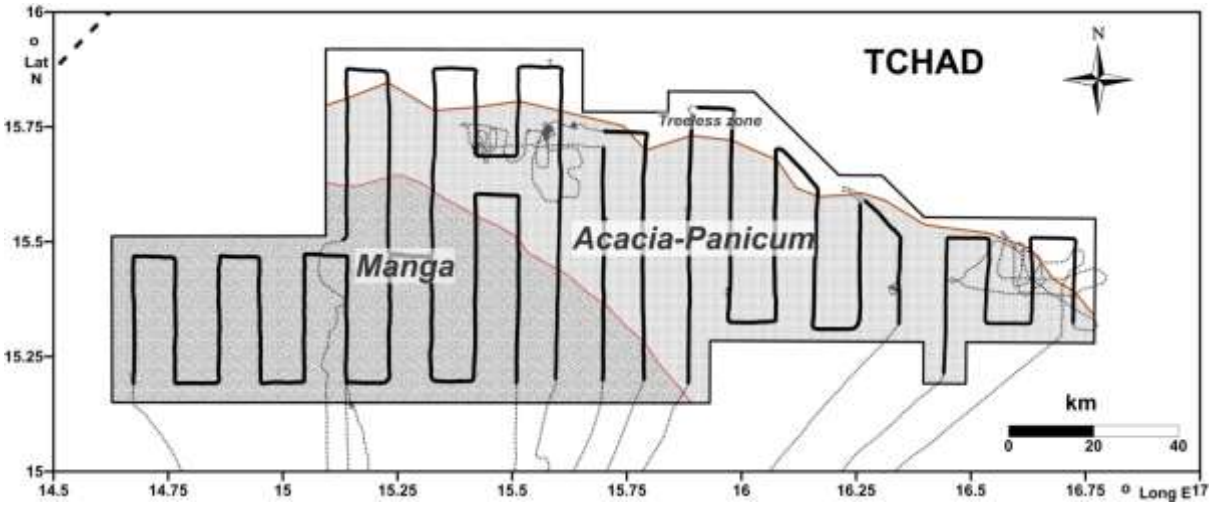
Ground survey: The ground survey team consisted of two vehicles. The observation team consisting of one driver- observer, one recorder-observer and one observer in the lead vehicle. The ground survey objective was to duplicate part of the transect survey route of the air survey to provide a comparative data set on wildlife and livestock sightings (particularly dorcas gazelle and camels), investigate and follow up leads on possible dama information obtained from local nomads and supply up to date information to the air survey team. Following standard SCF protocols all wildlife observations were entered into a prepared Cybertracker sequence (www.Cybertracker.org). On transect sectors data were collected in line transect (Distance sampling) format. Daily meteorological records were stored at 3 hour intervals on a Kestrel hand held weather station (Annex I). Opportunistic camera trapping was conducted at overnight stops. (Annex V).

Co-ordination between ground and air survey team: Daily satellite telephone contact between the two teams enabled the ground team to update the air team on ground conditions and information on presence and location of dama signs. The latter proved crucial to finding dama. The air team was also able to forward locations of well sites and water, allowing the ground team to travel more efficiently towards areas of interest for dama detection.

Analysis: The aerial sample survey block was stratified into two principle habitat zones, representing the fixed vegetated dunes of the Manga and the Acacia-Panicum plains to the east of the Manga (Map 4). A third stratum, the 'treeless zone' represented a relatively small area at the northern fringe of the main survey zone. Aerial transect data were allocated to habitat strata and analysed using Jolly method for unequal transect lengths (Norton-Griffiths 1978 & Annex III). Ground survey data from transect sectors was analysed using the software Distance 6.0 (Thomas, Laake et al. 2009 & Annex IV).



Map 3. Survey zone (polygon)and all aerial survey routes overlaid on Google earth imagery of local habitats, western central Tchad. .



Map 4. Survey zone and survey transects overlaid on habitat strata: the Manga fixed dunes, the *Acacia-Panicum* plains and the ' treeless zone. Limits determined from a combination of satellite imagery (see Map 3) and ground truth experience. Aerial transects shown in bold black lines. Approach and departure routes, and free aerial search movements over areas where the ground team reported dama tracks, shown in pale grey lines.

RESULTS

Results for all livestock and larger wildlife sightings during strip transect flying are given with analysis of associated population estimates for each survey stratum in Annex III. Results of line transect ground survey analysis for dorcas and camel population estimates from distance sampling are given in Annex IV.

Results for individual species are summarised below.

ENVIRONMENTAL CONDITIONS

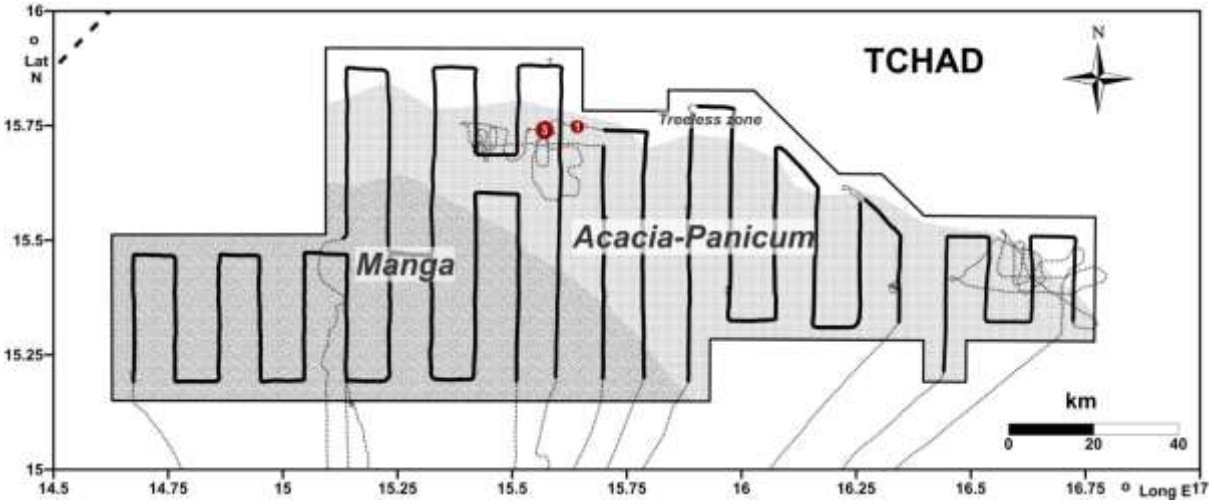
The survey took place in the mid dry season period. Weather records kept by the ground team are shown in Annex I.

- Wind speeds (mostly below 20km/hr before 9am) and visibility (mostly >5km with light haze) were both favorable throughout the survey period, with north-easterly airflow typical of the season.
- Humidity was low and vegetation notably dry. The ground team scored the grazing layer vegetation as <10% green at 66% of thirty-eight 5km recording stations.
- Appearance of the landscape in the three major strata is shown in Plate 1-4 and generally dry vegetation conditions are apparent in all the Plates .
- No natural surface water was observed by either survey team in the survey zone.

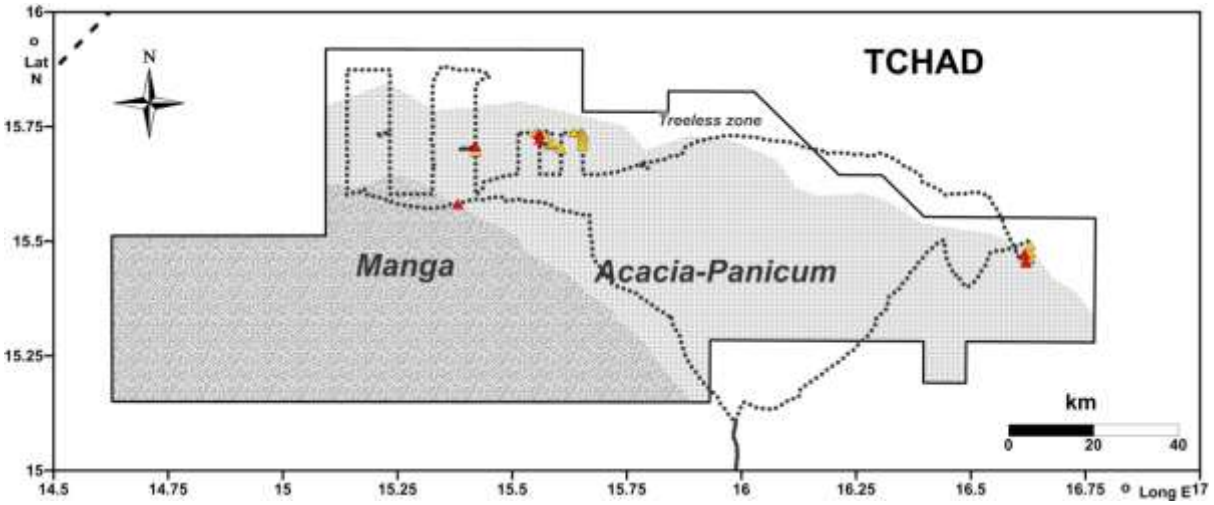
1) Dama gazelle *Nanger dama*

- No dama were seen while flying transects.
- Free searching from the air, in combination with information relayed by the ground team on location of fresh track sightings, resulted in discovery of two groups of dama on 16th February. Map 5 and Plate 3.
- All additional data on dama tracks and signs made on the ground are summarised in Map 6.
- Combined dama information from 2015 is compared with results in 2014 and 2001-2010 in Map 7.
- A group of three individuals consisted of one adult female accompanied by a younger adult female and young of year were observed towards the northern limit of the Acacia-Panicum habitat. The ground team were about 1.8 km distant to the south of the dama at the time. From the air the dama were observed moving away from the ground team in a north-easterly direction, using a mixture of walking and trotting gaits. They did not appear unduly alarmed by the presence of the aircraft, which circled them 5 or 6 times. At one point the dama were observed to stop and browse from a *Maerua crassifolia* shrub. They appeared to be aware of the ground team behind them, stopped to look in that direction and moved consistently away from them. In the course of observation they were seen to cross one of the main tracks used by heavy transport travelling north to Niger and Libya. They were thus in a very exposed position.
- A single adult male was found 6km to the east of the first group, apparently moving in a parallel direction. Like the females this individual appeared relatively calm in the presence of the aircraft. Although seen to run for one or two short bursts, this animal also stood to watch several passes by the aircraft. Like the others, he was located close to the lorry track and moving north towards the treeless zone.

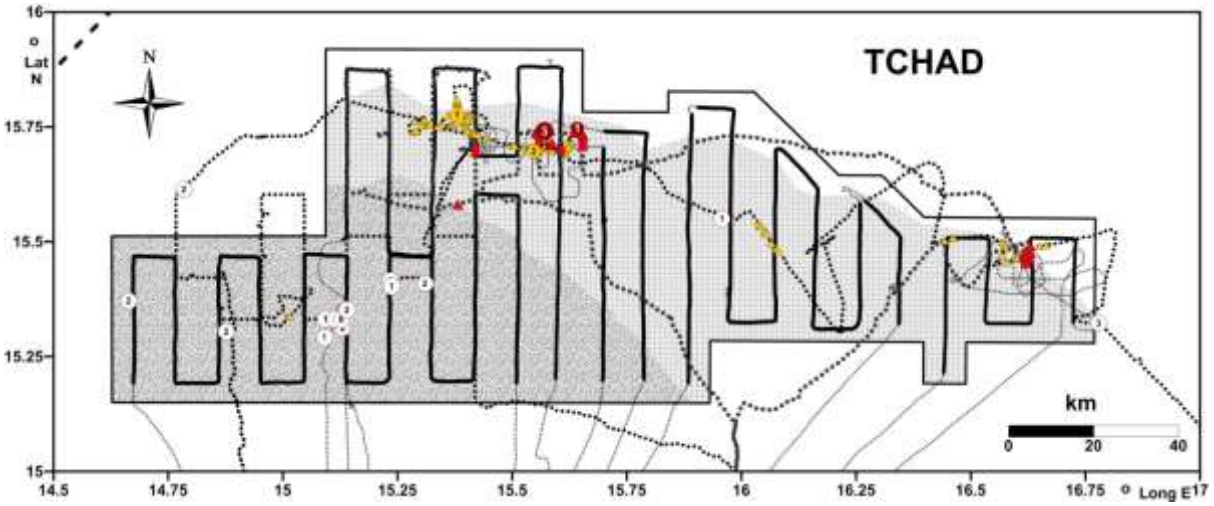
- On the ground fresh tracks of dama gazelle were frequently seen to indicate movements from shrub to shrub of *Leptadenia pyrotechnica.*
- A relatively fresh skull of a middle aged (adult dentition not heavily worn) female dama was found, with no associated skeleton, close to one of the main bush tracks in regular use by commercial and military vehicles.
- Besides direct observation of frequent heavy trucks travelling through the area in use by dama, the ground team recorded presence of military and police officials at check points intended to regulate this developing traffic.



Map 5. Location where two groups of dama gazelle were seen from the air, February 2015. Sightings made while free searching over an area where fresh tracks were reported by the ground survey team.



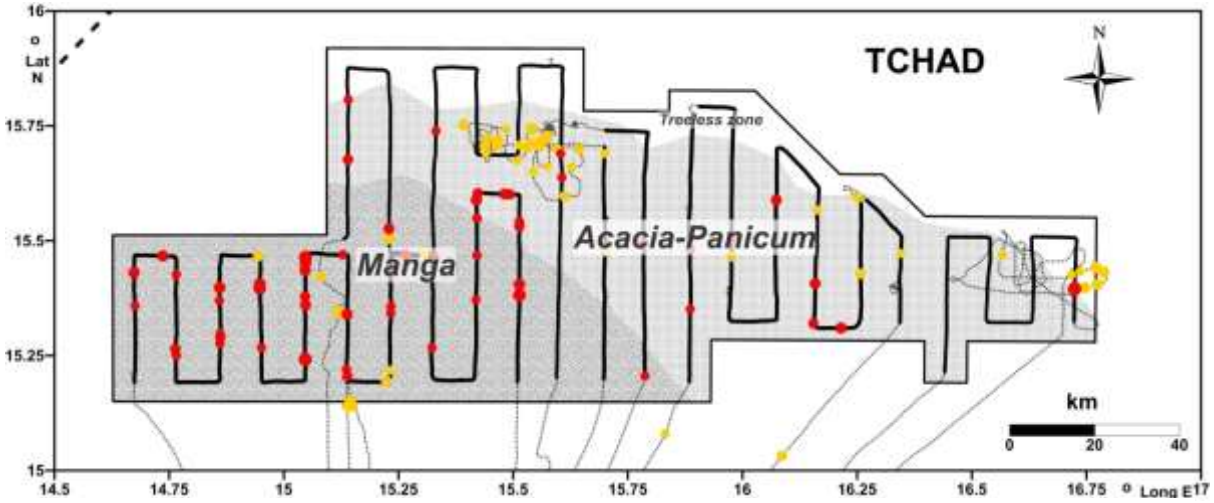
Map 6. Location of all tracks and signs of dama gazelle seen along survey route by the ground survey team, February 2015. Sites of dung sample collections (n=6) shown in red.



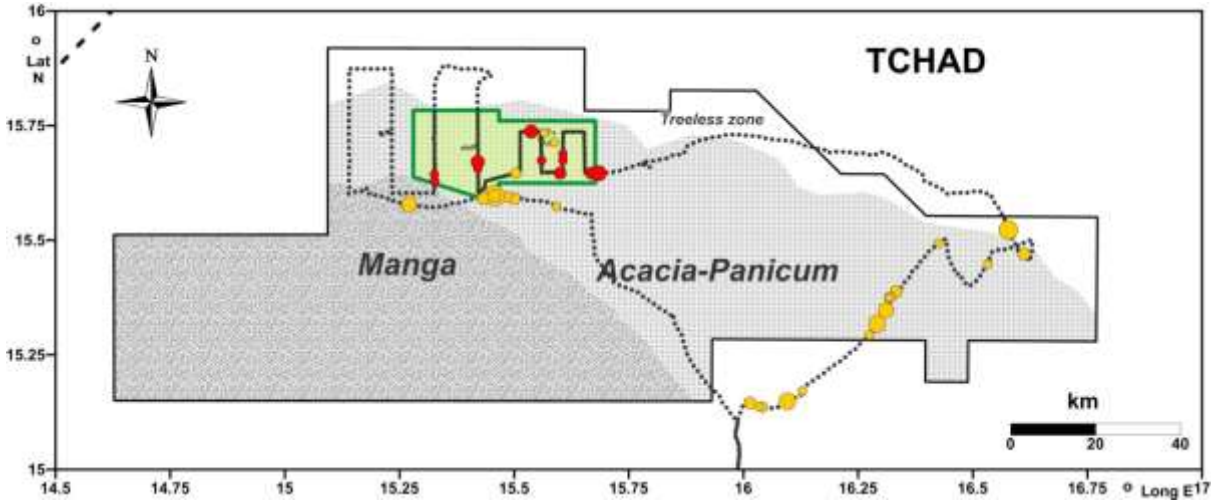
Map 7. All dama locations in 2015 (red) compared to 2014 (yellow), with all ground and air search routes in 2014 & 2015 indicated. All direct observations of live dama 2001-2010 also shown (white).

2) Dorcas gazelle *Gazella dorcas*

- A total of 330 dorcas gazelles were counted in 133 groups during all flying. This includes all animals seen *en route* to the sample zone, animals seen during free searching and all animals seen inside and outside the transect bandwidth during transect flying.
- A subset of 178 gazelles in 64 groups were recorded inside the 300m strip widths during transect flying. Map 8.
- Dorcas density recorded from the aerial survey was 0.5 / km^2 in the Manga and at 0.13 / km^2 in the Acacia-Panicum plains, Table 1. Statistical confidence in the estimates was very low (c.v. >50%). Full analysis is shown in Annex 1.
- The ground team observed 103 dorcas in 41 groups during all reconnaissance and transect work Map 9.
- Conditions on the ground transect survey proved harsh. No gazelles were seen on the first two (most westerly) transects where proportionately more sand and very little tree cover was available (compare westernmost transects in Map 6 with habitat in Map 3). Analysis of ground transect work was consequently limited to the 6 easterly transects.
- A subset of 21 dorcas in 11 groups was encountered in the resulting transect survey. Their location and the restricted sample zone in the Acacia-Panicum habitat are shown in Map 9.
- Because 11 groups is too few for reliable application of line transect methods, the data were analysed as a separate stratum in Distance 6.0 using 2014 observations combined with 2015 observations to create a global detection function based on 83 observations.
- This provided a ground based dorcas density estimate of 0.67 / km^2 for the Acacia-Panicum ground survey zone in 2015. (see Map 9).
- Dorcas density estimates for the Acacia-Panicum habitat are compared between years using line transect methods in 2014 & 2015 and within the same year using line transect and aerial survey methods in Table 1 and Fig. 1.
- Results show that ground surveys using the same methodology in 2014 & 2015 returned similar results. Comparison of these results with a significantly lower density estimate obtained from the air survey implies that the aerial survey result may be affected by undercounting bias. Dorcas are the smallest and most cryptic species recorded on this survey, particularly when lying down and do not necessarily stand up when overflown (Plate 4), so undercounting, especially with the relatively wide strip width used to search for the much more obvious dama, would not be surprising.



Map 8. Distribution of all aerial dorcas observations in the survey zone; red points shows groups seen inside the transect strip and contributing to population estimate; orange shows groups seen outside transect strip count limits.



Map 9. Distribution of all ground-based dorcas observations in the survey zone; red points shows groups seen during line transect recordings used in population density estimate for transect survey zone (green); orange shows all other groups. Dotted line shows vehicle route. .

Date	Method	Density / km2 +/- 95% C.I.
Feb 2014	Ground survey line transect (Distance6) Truncated @400m	0.9 (0.4-1.9)
Feb 2015	Ground survey line transect(Distance6) Truncated @400m	0.67 (0.32-1.4)
Feb 2015	Aerial survey strip transect (300m x2)	0.13 (0.03-0.23)

Table 1. Methods and results for dorcas density estimates in the *Acacia-Panicum* habitat, 2014-2015.

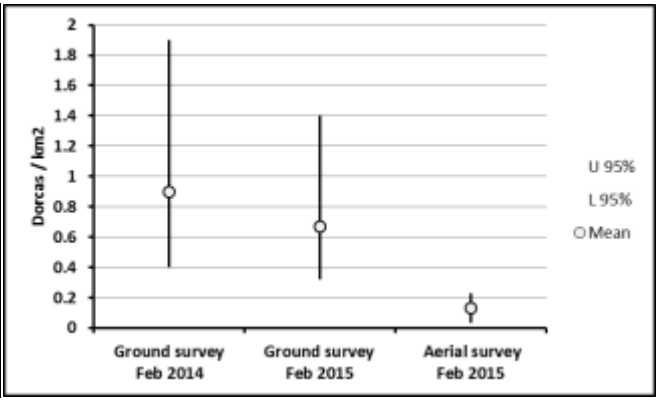


Fig. 1. Comparison of dorcas density estimates in the *Acacia-Panicum* habitat; see also Table 1.

3) Camels and livestock

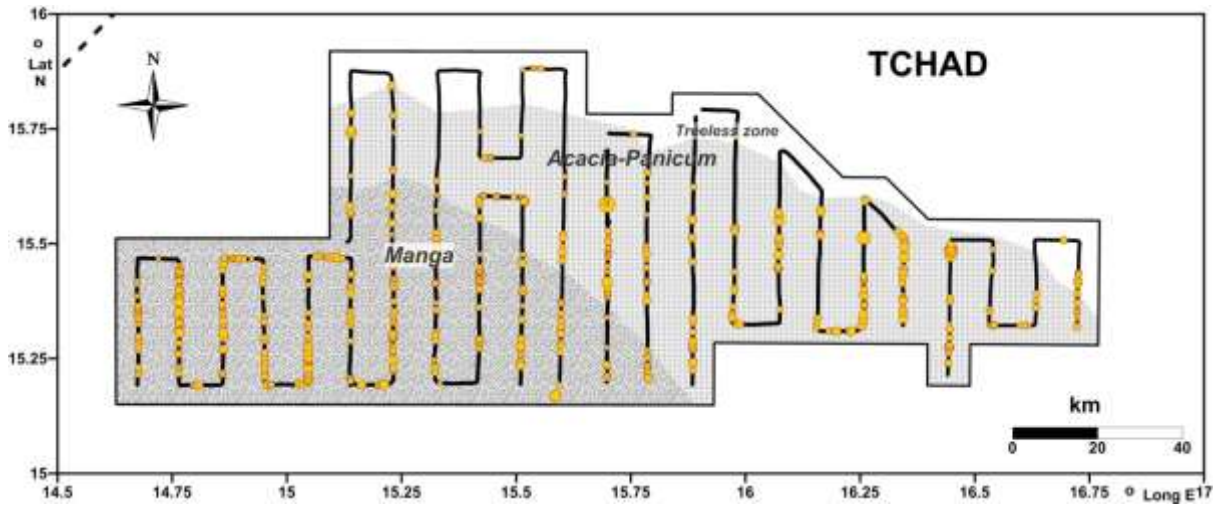
A summary of all livestock numbers seen on transect flights is given in Table 2. The distribution of all camel locations is shown in Map 10.

Table 2. Total livestock counted within the aerial survey strips.

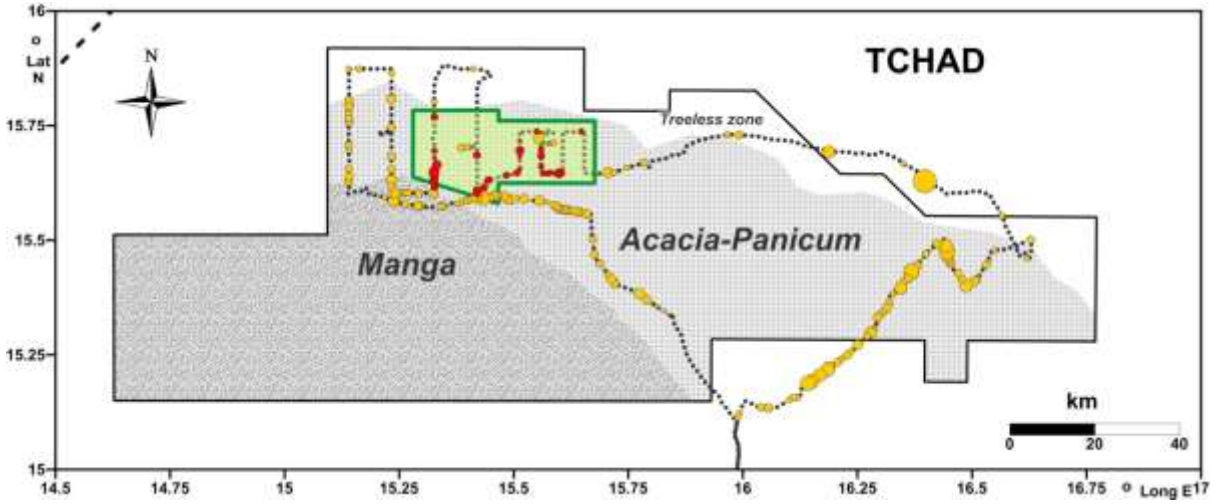
	Camels	Cattle	Donkey	Horse	Small stock
Manga	936	41	303	27	1186
Acacia-Panicum	926	-	82	-	75
Treeless zone	48				

- These figures translate to a combined density of just over 8 head of livestock / km^2 in the Manga and nearly 3 head of livestock /km^2 , in the *Acacia-Panicum* grasslands.
- Camel densities are slightly higher in the Manga, but the much greater presence of small stock and donkeys in the Manga were the main factors in this difference.
- Full analysis is shown in Annex II indicating nearly 16,000 (+/- 20%) camels in the Manga and nearly 14,000 (+/- 40%) camels in the Acacia-Panicum system. .
- After conversion of livestock and gazelle densities (Annex II) to livestock units (FAO, http: //www.fao.org/ag/againfo/programmes/en/lead/toolbox/Mixed1/TLU.htm) the results indicate that around 99% of all energy flow through grazing herbivores in the combined Manga & Acacia-Panicum system is under control of people.

- The ground team observed 1706 camels in 169 groups during all reconnaissance and transect work Map 11.
- A subset of 149 camels in 32 groups were recorded from transect routes in the transect survey zone (Map 11). These data were analysed as a separate stratum in Distance 6.0 using 2014 camel observations combined with 2015 observations. The resulting global detection function is based on 191 observations.
- This provided a ground based line transect estimate of camel density of 2.7 / km^2 for the Acacia-Panicum ground survey zone in 2015.
- Camel density estimates for the Acacia-Panicum habitat are compared between years using line transect methods in 2014 & 2015 and within the same year using line transect and aerial survey methods in Table 3 and Fig.2.
- Results show a good correspondence between aerial and ground survey results for comparatively easily visible camels.



Map 10. Distribution of all aerial camel observations in the survey zone; .



Map 11. Distribution of all ground based camel observations. Red points shows groups seen during line transect recordings used in population density estimate for transect survey zone (green); orange shows all other groups. Dotted line shows vehicle route.

Date	Method	Density / km2 +/- 95% C.I.
Feb 2014	Ground survey line transect (Distance6) Truncated @400m	3.9 (2.2-7.0)
Feb 2015	Ground survey line transect(Distance6) Truncated @400m	2.7 (1.7-4.5)
Feb 2015	Aerial survey strip transect (300m x2)	2.3 (1.8-2.7)

Table 3. Methods and results for camel density estimates in the *Acacia-Panicum* habitat, 2014-2015.

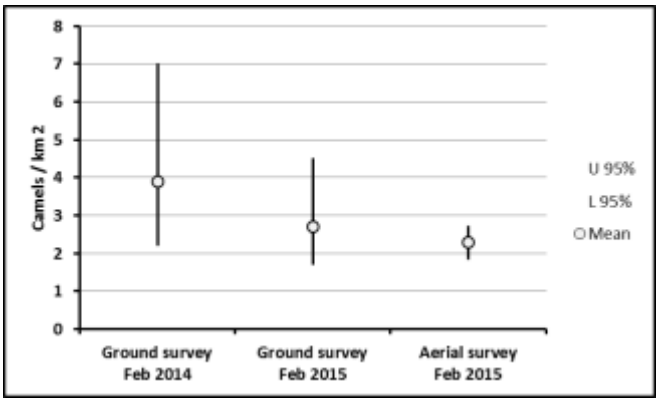
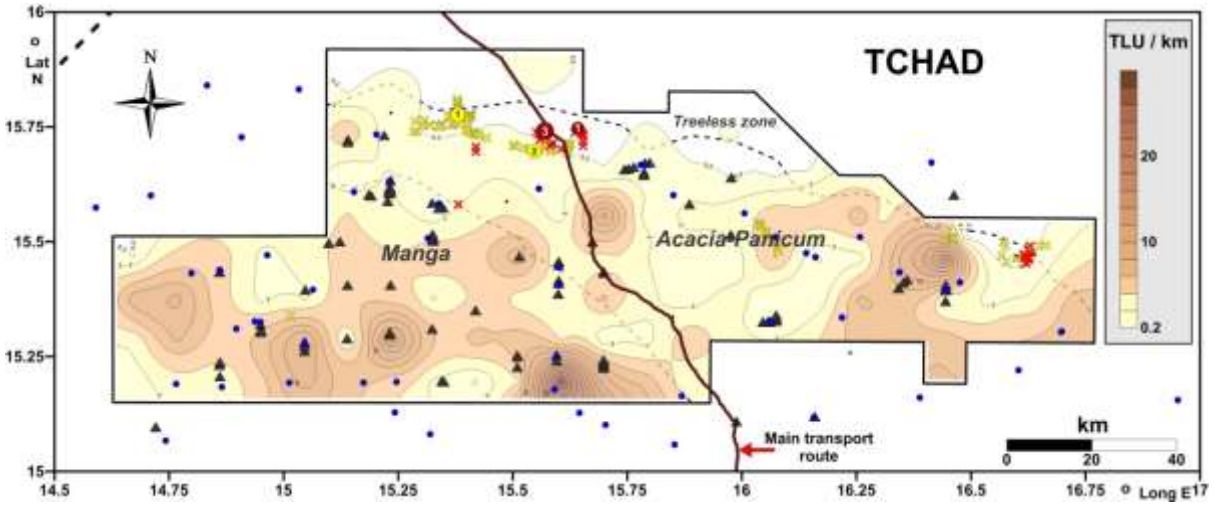


Fig. 2. Comparison of camel density estimates in the *Acacia-Panicum* habitat; see also Table 3.

DISTRIBUTION OF DAMA, LIVESTOCK AND NOMADS

The distribution of critically endangered dama gazelles in the Manga region is examined in relation to the distribution of livestock and human activity in Map 12.

- Although seen several times in the Manga in 2001 & 2010, only local reports and some old tracks were recorded in 2014 and no dama were seen in the Manga dune system from the air in this survey.
- After searching the area widely, the only locations where dama have been detected in 2015 lie at the northern limit of the vegetated habitats on the Acacia-Panicum plains.
- The places where dama were found co-incides with parts of the northern limit of wooded grassland habitat where livestock and human presence were minimal.
- The places where dama were found in 2014 and 2015 were essentially the same.
- Habitat to the north of this limit is effectively treeless and rapidly becomes fully Saharan.
- Map 12 illustrates the way dama gazelles in this area are marginalised to the limits of their preferred habitat.



Map 12. Location of dama gazelles in Feb. 2015 (red symbols) and Feb. 2014 (yellow symbols) in relation to livestock distribution, livestock camps and principal commercial transport route north; February 2015. Circular symbols indicate dama sightings and group size; crosses indicate dama tracks and signs recorded by ground teams. Contours derived by converting mixed species livestock counts to total tropical livestock units summed along each 5km sector of aerial transect survey route, assigning the resulting observation rate to the centre point of the sector and interpolating using Kriging. Blue points indicate known wells, and black triangles indicate all nomad encampments observed in February 2015.

CONCLUSIONS & RECOMMENDATIONS

The survey methodology has provided a detailed overview of the distribution and status of dama gazelle in relation to livestock and human activity in the Manga and nearby grasslands of western Chad.

- Disappointingly the evidence suggests that the large area of extent over which dama have been recorded in this zone does not indicate a relatively large population.
- The survey has provided further illustration of the way dama appear to be avoiding areas of increased livestock density and human activity and results suggest that the population is fragmented and at risk from increasing human activity.
- Coordinated aerial and ground survey proved effective in locating a very rare target species
- Comparison of ground and aerial survey results provided valuable evidence that aerial survey, in the configuration used, was missing a significant proportion of comparatively small and cryptic dorcas gazelles, but both methods provided similar results for more easily observed camels. Modifications such as a narrower strip width and smaller survey zone may be implicated for aerial dorcas survey in future.
- The impact of this effect on dama observation could not be directly assessed, but it is clear that the contrasting white and dark colouring of the dama was much more easily visible than dorcas (Plate 3 & 4). Whilst some may have been missed it is not likely this happened frequently enough to alter the essential result.
- Local nomads indicated a strong awareness of the dama, providing reliable information on their whereabouts and consistently remarking on the negative trend in their numbers.
- The increasing presence of commercial traffic presents a particular risk. Comments are provided below on steps needed to address this.
- Strategically the Manga area is extremely difficult to patrol and monitor. Nevertheless steps to re-inforce sensitisation and enforcement of national wildlife law at all levels of authority in the local towns and communities, including the security agencies charged with monitoring the main commercial traffic route, are necessary steps to protect the dama gazelle in western Chad. The trans-border conservation project being planned under EU funding and managed by the Sahara Conservation Fund will provide resources and a mechanism to help achieve this in the near future.

Chad is a key nation for the conservation of dama gazelle in the wild. Results of the survey underscore the opportunity to develop a national approach to dama conservation. In addition to promoting awareness in the Manga area as recommended above, the principle actions should be taken where infrastructure and management opportunities are better developed. Specific measures recommended are:

- Develop a program to re-inforce the very small remnant population the Ouadi Rimé-Ouadi Achim Game reserve, using captive captive bred animals (suitable stock are available from a range of zoos, ranches and private collections, particularly in the US and Gulf regions) and the infra-structure being developed for scimitar-horned oryx re-introduction.
- Explore opportunities for future re-introduction of dama gazelle to the Ennedi within the management program currently being developed by African Parks Network for that region.

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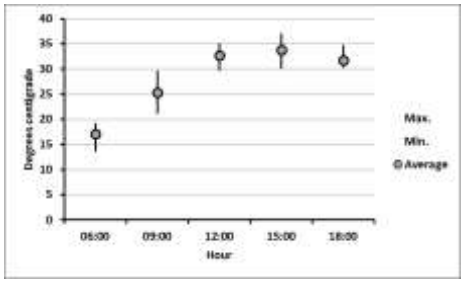
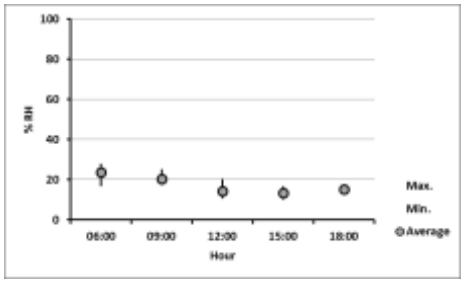
ANNEX I Meteorological records:

Date	Time	Latitude	Longitude	Temperature oC	Humidity %	Wind speed av. (km/hr)	Wind speed max. (km/hr)	Wind direction	Visibility	CLOUD STATUS
12/02/2015	06:11:11	14.4301362	15.7034972	17.5	25.2	13.7	15.1	NE (35-56)	> 1 km < 5 km	Low Stratus
12/02/2015	09:01:20	14.7660937	15.9585779	24.5	17.2	17.6	23.4	NE (35-56)	> 1 km < 5 km	No cloud
12/02/2015	12:05:02	15.3255215	15.8485861	31.5	10.7	21.6	28.8	ENE (57-78)	> 1 km < 5 km	No cloud
12/02/2015	15:03:01	15.4725073	15.6749718	30	10	19.1	25.6	ENE (57-78)	> 1 km < 5 km	No cloud
13/02/2015	06:03:11	15.5876253	15.4868382	13.6	20.3	3.2	5.8	ENE (57-78)	> 5 km (some haze)	No cloud
13/02/2015	09:00:34	15.5825367	15.3838164	21.1	17.5	14	18.7	ENE (57-78)	> 5 km (some haze)	No cloud
13/02/2015	12:14:20	15.6712438	15.1413211	30	12.3	19.4	25.6	NE (35-56)	> 1 km < 5 km	
13/02/2015	15:00:29	15.7719832	15.1405683	32.1	13.2	18.4	24.8	NE (35-56)	> 5 km (some haze)	No cloud
13/02/2015	17:41:32	15.7804173	15.2337818	30.3	14	11.9	15.5	NE (35-56)	Bright and clear	No cloud
14/02/2015	06:02:29	15.7804243	15.2338606	15.8	23.9			No wind	Bright and clear	No cloud
14/02/2015	09:00:49	15.7367954	15.2257896	26.5	17.4	5	6.1	East (79-101)	> 5 km (some haze)	No cloud
14/02/2015	12:38:25	15.6672747	15.3324154	34.7	13.5	14	15.8	East (79-101)	> 5 km (some haze)	No cloud
14/02/2015	14:59:50	15.7219642	15.3236058	37	13.3	5	8.6	East (79-101)	> 5 km (some haze)	No cloud
14/02/2015	17:51:24	15.8598598	15.4507857	34.7	13.9	0.4	2.2	East (79-101)	> 5 km (some haze)	No cloud
15/02/2015	05:59:50	15.8597338	15.4506134	17.4	27.9			No wind	> 5 km (some haze)	No cloud
15/02/2015	09:02:32	15.7490096	15.4200928	29.7	18.7	4.3	5.8	SE (124-146)	> 5 km (some haze)	No cloud
15/02/2015	12:00:01	15.6293483	15.4198741	35.1	13.7	14.8	21.6	NNE (12-34)	> 1 km < 5 km	No cloud
15/02/2015	15:11:46	15.6473429	15.5125514	37	13	5.4	10.4	North (349-11)	> 1 km < 5 km	No cloud
15/02/2015	17:51:53	15.7128842	15.5892066	33.5	14.1	4.3	5.4	NW (304-326)	> 5 km (some haze)	No cloud
16/02/2015	06:04:36	15.7128289	15.589265	18.9	24.5	1.8	3.2	NW (304-326)	> 5 km (some haze)	No cloud
16/02/2015	09:18:21	15.7356196	15.5595736	27	23.8	9	12.2	NE (35-56)	> 5 km (some haze)	No cloud
16/02/2015	12:04:52	15.6918713	15.6068357	33.9	15.9	5.4	7.9	NE (35-56)	> 5 km (some haze)	No cloud
16/02/2015	15:01:07	15.7366314	15.6366699	37.1	13.7	5	7.2	S W (214-236)	> 5 km (some haze)	
16/02/2015	18:31:22	15.6613301	15.7947658	31	16.4	4	5.4	NW (304-326)	> 5 km (some haze)	No cloud
17/02/2015	06:01:52	15.6616259	15.7948176	19.3	22.3	6.5	8.3	North (349-11)	> 1 km < 5 km	No cloud

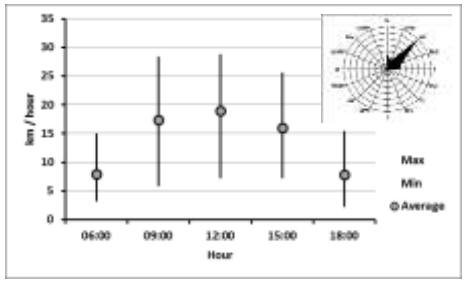
Date	Time	Latitude	Longitude	Temperature oC	Humidity %	Wind speed av. (km/hr)	Wind speed max. (km/hr)	Wind direction	Visibility	CLOUD STATUS
17/02/2015	09:00:11	15.687176	15.86029	24.1	20.2	22.3	28.4	North (349-11)	> 5 km (some haze)	No cloud
17/02/2015	13:19:36	15.6927561	16.3018489	32.8	13.1	21.2	28.4	NNE (12-34)	> 1 km < 5 km	No cloud
17/02/2015	14:52:34	15.6542307	16.3745297	31	12.8	21.2	23.4	North (349-11)	> 1 km < 5 km	No cloud
18/02/2015	05:59:15	15.4696001	16.5999712	15	16.6	2.9	5.4	North (349-11)	> 5 km (some haze)	No cloud
18/02/2015	09:00:02	15.4815177	16.6294355	24	25.2	13.7	16.6	NE (35-56)	> 5 km (some haze)	No cloud
18/02/2015	12:00:50	15.4261555	16.4647471	29.7	20.3	6.1	7.2	NE (35-56)	> 5 km (some haze)	No cloud
18/02/2015	15:01:41	15.5024157	16.4429095	31.5	16.8	7.9	10.4	NE (35-56)	> 5 km (some haze)	Low Stratus
18/02/2015	18:04:17	15.2583934	16.2362294	30.3	16.3	6.5	9.4	NE (35-56)	> 5 km (some haze)	Low Stratus
19/02/2015	06:04:49	15.2582758	16.2363073	19.2	27.8	6.1	9.7	NE (35-56)	> 5 km (some haze)	6-25 % cloud; Low Stratus
19/02/2015	09:01:32	15.1350085	16.0733774	25.7	22.4	22	27.7	ENE (57-78)	> 5 km (some haze)	6-25 % cloud; Low Stratus
19/02/2015	12:20:30	14.5791623	15.7802761	33.4	15.5	9	16.6	NE (35-56)	> 5 km (some haze)	51 - 75 % cloud; Low Stratocumulus
19/02/2015	15:00:45	14.2816564	15.5389537	34.1	14.3	14.4	17.3	NNE (12-34)	> 5 km (some haze)	26 - 50 % cloud; Low Stratus
19/02/2015	18:00:49	14.1131712	15.3153009	30.9	16.4	4	9.4	NE (35-56)	> 1 km < 5 km	6-25 % cloud; Low Stratus



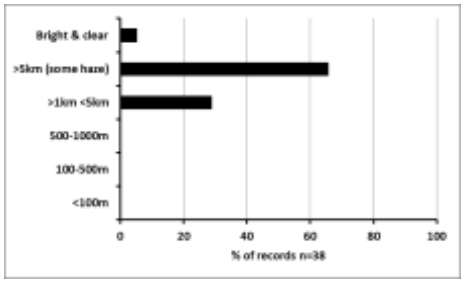
Daily temperature range



Daily humidity range



Wind speed and direction



Visibility scores

ANNEX II AIRCRAFT SET UP FOR STRIP COUNT SURVEY

Aircraft set up and strip width management was based on Norton-Griffiths 1978. Strip width markers are set on the wing struts by aligning them with each observers eye position in the aircraft (h) and a marker set out on the ground at a distance from the aircraft (w) determined by the expected altitude (H)and required strip width (W). Fig. 1 & 2.

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Fig. 1. Mahamat Hassan Hatcha (DCBPNC) and Darren Potgieter (APN), adjusting wing strut marker for observer Satangar Dogringar (APN).

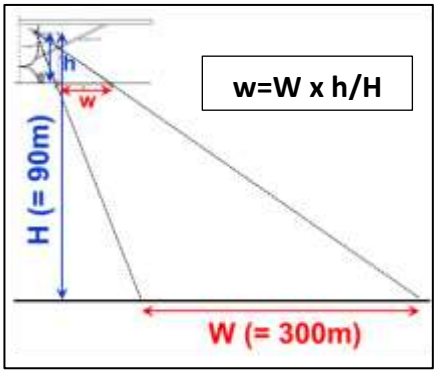


Fig. 2. Measurements used for wing strut marker positioning.

During transect counting actual altitude is recorded at regular intervals (Fig. 3) to obtain an average realised altitude for each stratum. Actual effective strip width is derived by substituting actual mean altitude (H) into the rearranged formula **W = H x w/h** Table 1.

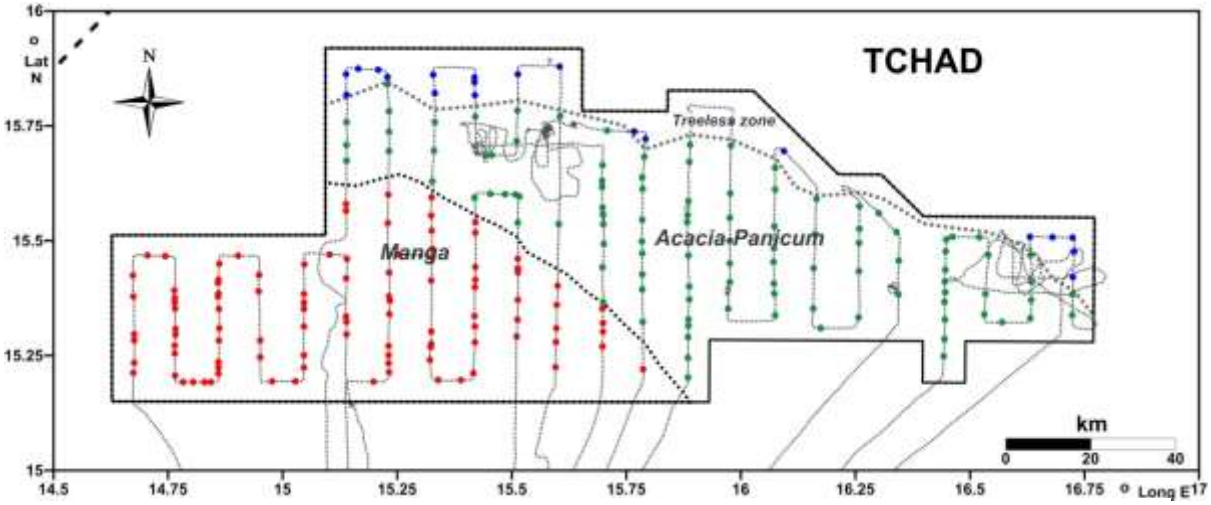


Fig. 3. Location of all spot height measurements made during transect flying over three habitat strata.

Table 1. Corrected sample strip widths based on realised average altitude.

	Observer	Mean Alt. (H)	Eye ht. (h)	w	Effective W (m)	
AP	Mahamat	95.7	1.41	4.7	319	638
	Satangar	95.7	1.47	4.9	319	
Manga	Mahamat	96.4	1.41	4.7	321	643
	Satangar	96.4	1.47	4.9	321	
TZ	Mahamat	91.6	1.41	4.7	305	611
	Satangar	91.6	1.47	4.9	305	

ANNEX III

AERIAL SURVEY RESULTS: STRATUM 1:THE MANGA

Total area : 5103 km^2
Total sample units (N) : 202
Total samples (n) : 13
Average altitude: : 96.4m (n=103)
Sample fraction : 5.9%

Transect	Length km	Width km	Area km2 (z)	Camels (y)	Cattle (y)	Donkey (y)	Horse (y)	Shoats (y)	Dorcas (y)	Nubian bustard (y)
1	35	0.643	22.5	46	0	41	0	40	5	0
2	40	0.643	25.7	134	0	16	2	11	10	9
3	40	0.643	25.7	79	0	28	0	9	10	7
4	40	0.643	25.7	55	26	1	1	42	19	4
5	40	0.643	25.7	116	0	31	0	128	41	7
6	47.1	0.643	30.3	77	0	51	0	90	8	6
7	49.1	0.643	31.6	147	0	32	0	175	10	0
8	45.8	0.643	29.4	61	15	4	7	67	3	1
9	39.6	0.643	25.5	66	0	0	1	133	3	0
10	34.6	0.643	22.2	62	0	40	5	211	15	0
11	26.2	0.643	16.8	53	0	53	2	200	0	2
12	18.9	0.643	12.2	15	0	0	9	80	0	0
13	9.1	0.643	5.9	25	0	6	0	0	1	6
Σz			299.3	299.3	299.3	299.3	299.3	299.3	299.3	299.3
Σy				936	41	303	27	1186	125	42
Σz**2** or Σy2			7542.815	85912	901	11769	165	171774	2675	272
Σz.y				23962.42	1110.46	7367.94	563.08	28433.14	3232.43	974.40
Density R =Σy/Σz				3.13	0.14	1.01	0.09	3.96	0.42	0.14
sy2				1543.33	64.31	392.23	9.08	5297.86	122.76	11.36
sz2				54.52	54.52	54.52	54.52	54.52	54.52	54.52
szy				201.36	13.89	32.76	-4.87	94.34	29.58	0.63
Population Estimate Y				**15961**	**699**	**5167**	**460**	**20224**	**2132**	**716**
Var Y				2399590.7	180685.6	1121231.5	30541.4	15877215.2	315861.8	35991.2
SE Y				1549.1	425.1	1058.9	174.8	3984.6	562.0	189.7
95% cl Y t=2.1				3253.0	892.6	2223.7	367.0	8367.7	1180.2	398.4
cl as % Y				20.4	127.7	43.0	79.7	41.4	55.4	55.6

ANNEX III Cont'd.

AERIAL SURVEY RESULTS: STRATUM 2: : *Acacia-Panicum* plains

Total area : 6058 km^2
Total sample units : 282
Total samples : 18
Average altitude : 95.7m (n=105)
Sample fraction : 6.7%

Transect	kms	Width km	Area km2	Camels	Cattle	Donkeys	Horse	Shoats	Dorcas	Nubian bustard
1	21.1	0.638	13.5	31	0	6	0	0	3	2
2	23	0.638	14.7	12	0	0	0	0	0	3
3	19.4	0.638	12.4	2	0	12	0	0	1	0
4	26.4	0.638	16.8	29	0	0	0	0	6	5
5	32.9	0.638	21.0	25	0	5	0	0	10	2
6	38.4	0.638	24.5	20	0	9	0	0	2	2
7	42.4	0.638	27.1	118	0	16	0	0	0	4
8	55.2	0.638	35.2	31	0	4	0	10	1	3
9	59.4	0.638	37.9	59	0	11	0	0	2	2
10	48.8	0.638	31.1	40	0	0	0	0	1	0
11	43.6	0.638	27.8	64	0	0	0	0	3	2
12	36.8	0.638	23.5	42	0	3	0	0	5	0
13	40.4	0.638	25.8	115	0	4	0	60	4	5
14	26.9	0.638	17.2	105	0	4	0	0	0	0
15	37.6	0.638	23.9	156	0	5	0	5	0	1
16	30.1	0.638	19.2	29.0	0	0	0	0.0	0.0	0
17	30	0.638	19.1	22	0	0	0	0	0	0
18	25	0.638	15.9	26	0	3	0	0	15	1
Σz			406.7	406.7		406.7		406.7	406.7	406.7
Σy				926.0		82.0		75.0	53.0	32.0
Σz2 or Σy2			10100.7	79388.0		754.0		3725.0	431.0	106.0
Σz.y				22553.9		1955.3		2018.6	1098.1	760.2
Density R =Σy/Σz				**2.28**		**0.20**		**0.18**	**0.13**	**0.08**
sy2				1867.7		22.38		200.7	16.2	2.89
sz2				53.7		53.7		53.7	53.7	53.7
szy				96.09		6.04		19.07	-5.84	2.19
Population Estimate Y				**13795**		**1222**		**1117**	**790**	**477**
Var Y				7066962.8		91517.1		808704.4	76965.9	11896.6
SE Y				2658.4		302.5		899.3	277.4	109.1
95% cl Y t=2.1				5582.6		635.3		1888.5	582.6	229.1
cl as % Y				40.5		52.0		169.0	73.8	48.0

ANNEX III cont'd.

AERIAL SURVEY RESULTS: STRATUM 3: Treeless zone

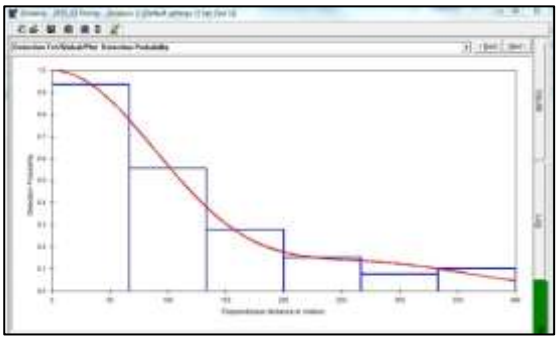
Total area : 1725 km^2
Total sample units : 213
Total samples : 13
Average altitude: : 91.6m (n=21)
Sample fraction : 5.2%

Transect	kms	Width	Area km2	Camels	Cattle	Donkey	Horse	Shoats	Dorcas	Nubian bustard
TZ01	11.9	0.611	7.2709	0	0	0	0	0	0	0
TZ02	6.9	0.611	4.2159	0	0	0	0	0	0	0
TZ03	14.8	0.611	9.0428	0	0	0	0	0	0	0
TZ04	14	0.611	8.554	0	0	0	0	0	0	0
TZ05	12.6	0.611	7.6986	5	0	0	0	0	0	2
TZ06	14.8	0.611	9.0428	0	0	0	0	0	0	0
TZ07	8.1	0.611	4.9491	2	0	0	0	0	0	0
TZ08	9	0.611	5.499	0	0	0	0	0	0	0
TZ09	12.4	0.611	7.5764	2	0	0	0	0	0	0
TZ10	9.7	0.611	5.9267	0	0	0	0	0	0	0
TZ11	8.3	0.611	5.0713	0	0	0	0	0	0	0
TZ12	7.7	0.611	4.7047	0	0	0	0	0	0	0
TZ13	17.8	0.611	10.8758	39	0	0	0	0	0	0
Σ			90.428	48	0	0	0	0	0	2

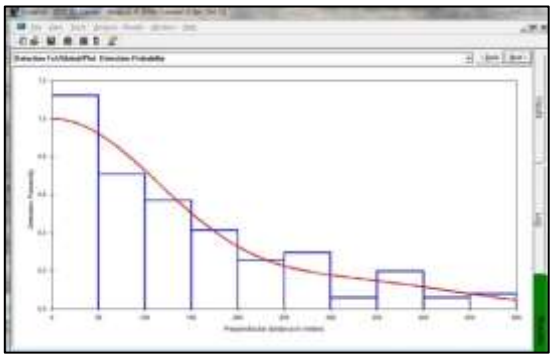
ANNEX IV – GROUND SURVEY LINE TRANSECT ANALYSIS

Output of Distance 6.0 comparing dorcas and camel records from line transect sampling in the Acacia-Panicum habitat, 2014 & 2015, using a global detection function from both years to increase sample size. [Note: population estimates below are not comparable as they apply to different sized sample zones in each year; the densities are better comparative measures].

DORCAS				
Acacia/Panicum Feb 2014	**Estimate**	**%CV**	**df**	**95% c.i.**
Half-normal/Cosine				
D (Density)	0.79	32.09	12.62	0.4 - 1.5
N (Population estimate)	2264	32.09	12.62	1149 - 4462
Acacia/Panicum Feb 2015	**Estimate**	**%CV**	**df**	**95% c.i.**
D (Density)	0.67	34.55	13.75	0.3 - 1.4
N (Population estimate)	511	34.55	13.75	248 - 1052



CAMELS				
Acacia/Panicum Feb 2014	**Estimate**	**%CV**	**df**	**95% c.i.**
Half-normal/Cosine				
D (Density)	3.3	28.63	26.02	1.8-5.8
N (Population estimate)	9349	28.6	26.02	5251 - 16645
Acacia/Panicum Feb 2015	**Estimate**	**%CV**	**df**	**95% c.i.**
D (Density)	2.7	24.74	63.09	1.7 - 4.5
N (Population estimate)	2097	24.74	63.09	1288 - 3413



ANNEX V CAMERA TRAPPING

The ground team set baited camera traps at overnight camp sites. Five species were recorded, with fennec accounting for just over 80% of events*. Jackal, hare hedgehog and small mammals made up the rest.

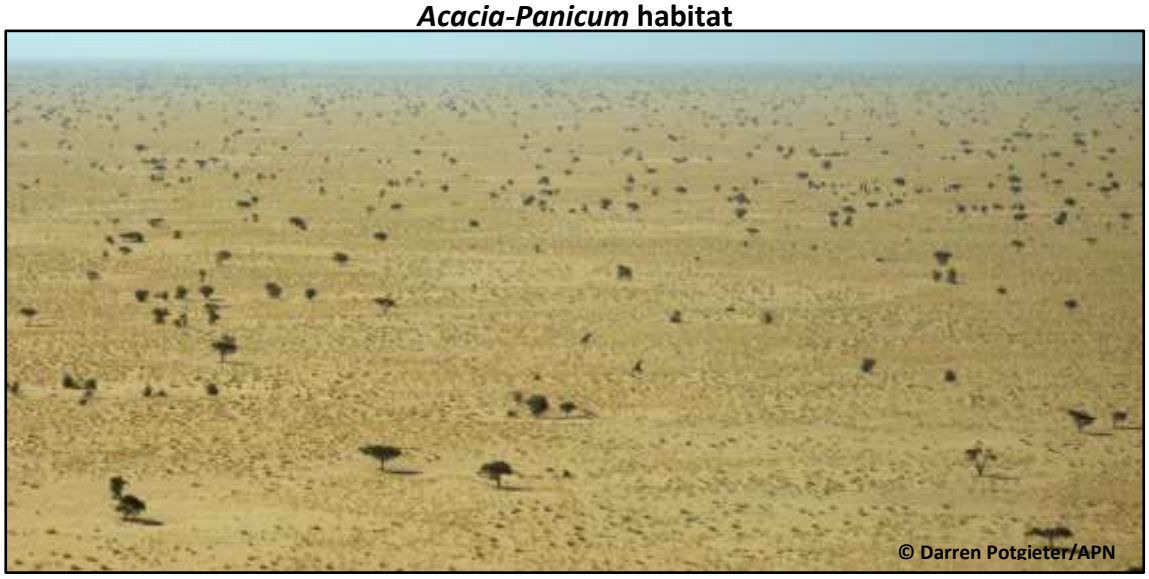
Camera	Lat.	Long.	Set up	Recovery	Hrs	Jackal	Fennec	Hare	Hedgehog	Gerbil (Unid.)
Reconyx01	14.4290	15.7020	11/02/2015 19:30	12/02/2015 06:10	10.67	0	0	0	0	0
Reconyx01	15.5870	15.4870	12/02/2015 19:30	13/02/2015 06:44	11.24	0	3	0	0	0
Reconyx03	15.5870	15.4880	12/02/2015 19:35	13/02/2015 06:50	11.25	0	2	0	0	1
Scoutguard 560C	15.5865	15.4885	12/02/2015 18:04	13/02/2015 07:00	12.93	0	0	0	0	0
Reconyx01	15.7810	15.2340	13/02/2015 18:12	14/02/2015 07:13	13.01	0	3	0	0	0
Reconyx03	15.7800	15.2320	13/02/2015 17:59	14/02/2015 07:06	13.13	0	5	0	1	0
Scoutguard 560C	15.7820	15.2310	13/02/2015 18:20	14/02/2015 07:09	12.83	0	3	0	0	0
Reconyx01	15.8590	15.4510	14/02/2015 18:04	15/02/2015 07:15	13.17	3	0	0	0	0
Scoutguard 560C	15.8580	15.4500	14/02/2015 18:19	15/02/2015 07:09	12.84	1	6	0	0	0
Reconyx01	15.7120	15.5910	15/02/2015 18:08	16/02/2015 06:55	12.79	0	5	1	0	0
Reconyx03	15.7120	15.5900	15/02/2015 18:00	16/02/2015 07:01	13.01	0	7	0	0	0
Scoutguard 560C	15.7110	15.5910	15/02/2015 18:18	16/02/2015 06:57	12.64	0	3	0	0	0
Reconyx01	15.4690	16.6000	17/02/2015 17:50	18/02/2015 06:46	12.94	0	0	0	0	0
Scoutguard 560C	15.4680	16.6010	17/02/2015 18:01	17/02/2015 18:01	0.00	0	0	0	0	0
Reconyx03	15.4670	15.5999	17/02/2015 19:07	18/02/2015 06:59	11.87	0	0	0	0	0
Scoutguard 560C	15.2555	16.2383	18/02/2015 18:00	19/02/2015 07:19	13.31	1	1	0	0	0
Reconyx01	15.2444	16.2382	18/02/2015 17:51	19/02/2015 07:20	13.48	0	0	0	0	0
TOTAL					**201.1**	**5**	**38***	**1**	**1**	**1**

* Numbers in species columns correspond to number of 'events' – defined as photos taken after a lapse of at least 30mins since previous photo of the same species.

PLATE 1 – HABITATS

The Manga

***Acacia-Panicum* habitat**



'Treeless' zone

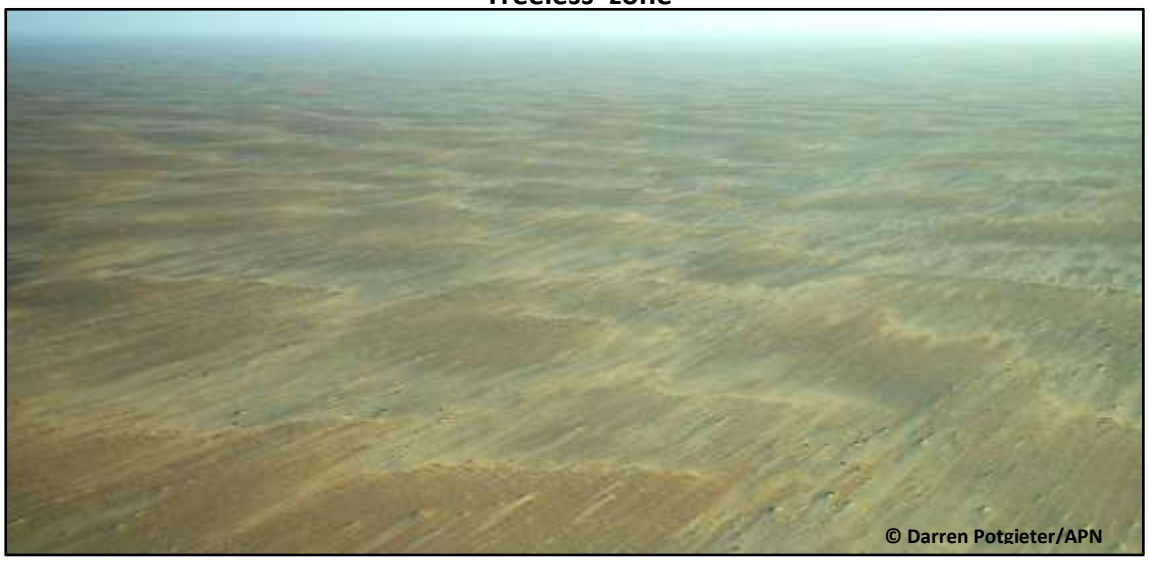


PLATE 2 – HUMAN LAND USE

Camel grazing

Well development

Lorries near the dama gazelles on the transport route illustrated in Map 12

PLATE 3 - DAMA GAZELLES

Adult females with young of year- 16 Feb 2015

Same adult female with young of year- 16 Feb 2015

Adult male - 16 Feb 2015

Plate 4 – OTHER WILDLIFE

Dorcas from the air - 16 Feb 2015

Dorcas

Fennec: note dense 'cool season' pelage

Arabian bustard