Aerial survey of African white-backed vulture colonies around Kimberley, Northern Cape and Free State provinces, South Africa

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Received 6 May 2002. Accepted 10 September 2002

Following preliminary ground surveys, microlight aircraft were used to conduct an aerial survey of African white-backed vulture (AWbV; *Gyps africanus*) breeding colonies in the Kimberley area, South Africa. Six colonies ranging from five to 135 km^2 in area (covering a total area of 506 km^2) were surveyed during June and July 2001. Ground and aerial surveys revealed 119 and 227 active nests, respectively. Total breeding population across the colonies was found to be higher than previous estimates and concluded to be approximately 240 pairs, with a concurrent census population estimated to be approximately 650 birds. Nest densities within colonies ranged from 0.32 to 0.61 nests per km^2 (mean 0.46/km^2), and were lower than previous estimates. Recorded population estimates and the aerial survey technique are discussed in relation to regional AWbV populations.

Key words: aerial survey, breeding colonies, *Gyps africanus,* microlight, population size.

INTRODUCTION

The total global population of African white-backed vultures (AWbV; *Gyps africanus*) has been estimated at 270 000 birds (Mundy *et al.* 1992), with the South African population numbering about 9000 individuals (Anderson 2000). Despite their relatively favourable numerical status, the AWbV is considered to have suffered a decline of 10% in recent years, and the species is now listed as 'vulnerable' in *The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland* (Anderson 2000). Threats to AWbVs include various anthropogenic-related factors, including secondary poisoning (Anderson 1995), electrocution on electricity pylons (Anderson & Kruger 1995; Kruger 1999; Van Rooyen 2000) and drowning in farm reservoirs (Anderson *et al.* 1999). Despite knowledge of isolated mortality incidents, there is no information about the relative importance of these different factors.

In South Africa, the AWbV occurs within and outside protected areas (Boshoff *et al.* 1997; Anderson 2000). In the Northern Cape the species occurs and breeds in the province's largest conservation area, the Kgalagadi Transfrontier Park, and mainly in two colonies on private farmland; one in the Askham area in the southern Kalahari and the other in the greater Kimberley area (Anderson & Maritz 1997). Approximately 80% of the Northern Cape's AWbV breeding pairs are located on private land (Anderson & Maritz 1997). There are estimated to be another 100 pairs of AWbVs breeding in the western areas of the Free State (Colahan & Esterhuizen 1997).

Nesting AWbVs have a marked preference for *Acacia* species, particularly the camel thorn tree (*Acacia erioloba*) (Mundy *et al.* 1992; Anderson & Maritz 1997). The species has been observed breeding on Dronfield farm to the northeast of Kimberley for at least 35 years (Forrester 1967), and this colony was studied during the mid-1970s (Mundy 1982). It has subsequently been monitored intensively since 1993 (M.D.A. & A.A., unpubl. data). Breeding has also occurred for over 40 years at the Riet River colony (F. Naudé, pers. comm.) to the southwest of Kimberley (Fig. 1). Based on historical information, it is unlikely that these breeding colonies have existed for more than 100 years. Early reports indicate that by the

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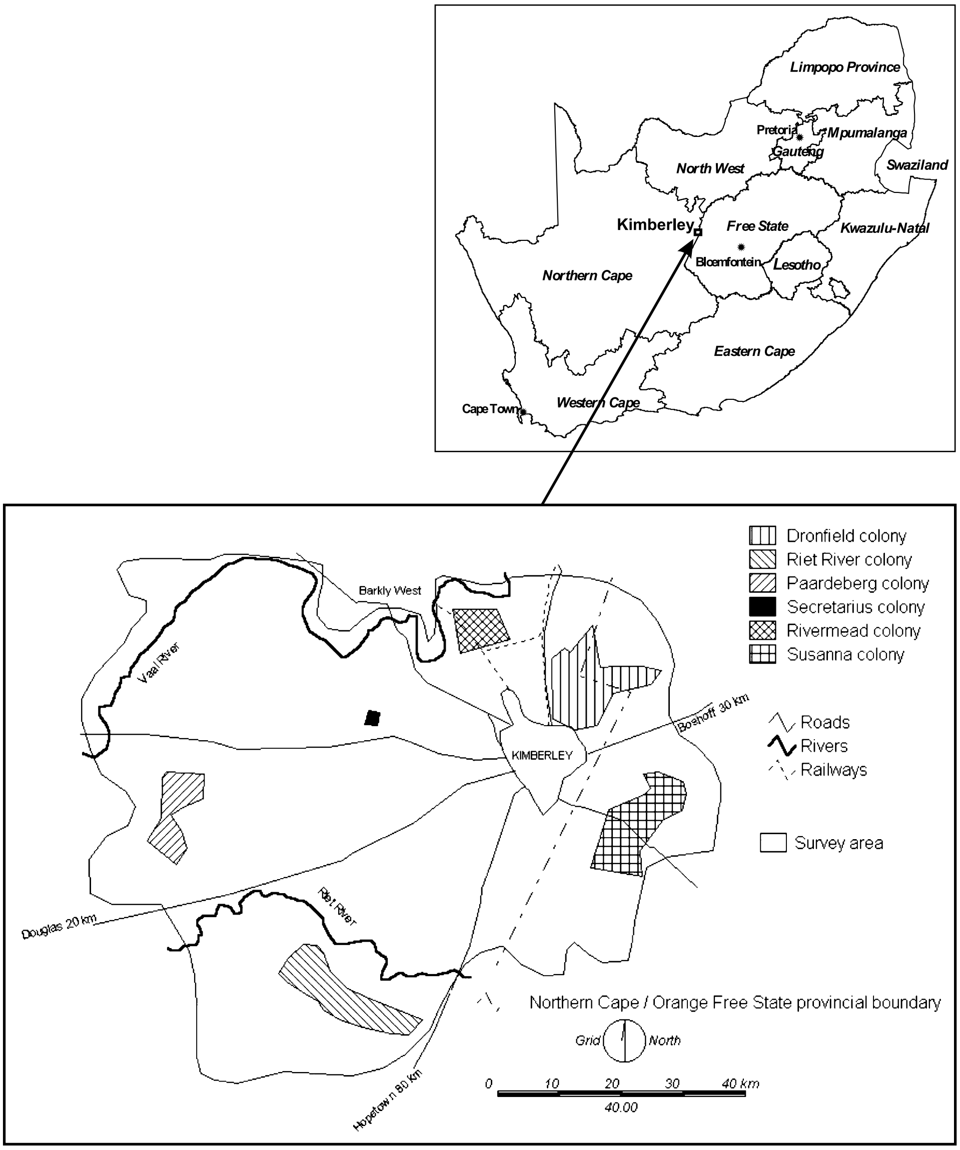

Fig. 1. The distribution of African white-backed vulture breeding colonies in the greater Kimberley area, South Africa.

late 19th century, virtually all *A. erioloba* trees within at least a 120 km radius of Kimberley had been removed for fuelwood and/or use in Kimberley's diamond mines (Matthews 1887; Fock 1972).

The size of the AWbV breeding population in the greater Kimberley area was estimated by Anderson & Maritz (1997) to consist of 110 breeding pairs. Nest densities for the species are variable, but in the Kimberley area have been previously recorded at between 1.1/km^2 (Mundy 1982; Mundy *et al.* 1992) and 6.1/km^2 (Forrester 1967). In July 2001, in an attempt to confirm the size and density of the breeding population, and as part of a long-term monitoring programme, the first aerial survey of AWbV breeding colonies was conducted in the Kimberley area. This paper describes the survey methods used and the results that were obtained.

METHODS

Study area

The surveyed vulture breeding colonies occur within a study area of approximately 4000 km^2, centred on the city of Kimberley, and extending from 28°30′S 24°05′E to 29°10′S 25°00′E. The terrain is generally flat, with scattered low hills (koppies) and occasional pans. Geologically, the study area is characterized by exposed dolerite and andesite outcrops, combined with extensive calcrete deposits (Visser 1984). Red-orange aeolian Kalahari sands overlay the calcrete, and are generally deeper than 300 mm (Anon. 1987).

The vegetation type is the 'Kimberley Thorn Bushveld' of the Savanna Biome (Low & Rebelo 1996). Dominant trees in these areas are from the genus *Acacia,* primarily *A. erioloba* and *A. mellifera* (blackthorn). Within the study area AWbVs breed exclusively in *Acacia* trees, and use *Acacia erioloba* for approximately 90% of nests (Murn, unpubl. data). Where soils become more structured and lime-prone, low shrubs such as camphor bush (*Tarchonanthus camphoratus*) and karee (*Rhus lancea*) replace *Acacia* trees (Gubb 1980; Low & Rebelo 1996). As a result, vulture breeding colonies are patchily distributed (Fig. 1), following the distribution of *Acacia* woodland.

Cattle and game farming are the main agricultural pursuits and account for 84.2% of land use, resulting in a low degree of habitat modification (Murn 2001). The frequency of vulture occurrence is most strongly related to available food, which is generally higher on properties with a combined cattle and game operation. There are at least five established feeding stations ('vulture restaurants') for vultures in the study area, and these restaurants are generally situated near the breeding colonies (Murn 2001).

Timing of the survey

All survey work was completed during June and July 2001. Prior to this, vultures can still be preparing for incubation, and from late July many chicks may have already hatched (Forrester 1967; C. Murn, unpubl. data). From August onwards, there is an increased possibility of desertion or abandonment, mortality of the embryo or nestling, and chick or egg predation. As a result, vultures are less likely to be seen at the nest. During late June and July, following a peak egg-laying period in May (Mundy *et al.* 1992; Anderson 2000), the highest proportion of birds attempting to breed will be attendant at their nests, thus providing an indication of maximum breeding productivity.

Ground survey

Prior to the aerial survey, ground surveys were conducted. These consisted of a landowner questionnaire and field investigations (Murn 2001). The ground surveys aimed to confirm the location of breeding colonies known from previous investigations (Anderson & Maritz 1997), and to reveal any new colonies in the area.

During the questionnaire interview, landowners were asked how often they saw vultures (never; infrequently; often; most days; every day), and how this frequency related to three types of vulture activity (feeding, roosting and breeding). All properties positive for roosting or nesting activity were investigated. The type and location of woodland areas on properties were queried and marked on 1:50 000 topocadastral maps. Subsequent field surveys confirmed these locations, investigated nesting activity and identified relevant landmarks for use during the aerial survey.

Aerial survey

Prior to the current study, aerial surveys of African vultures have concentrated on the Cape griffon (*Gyps coprotheres*) and Rüppell's griffon (*Gyps rueppellii*), which are colonial, cliff-nesting species (Tarboton & Benson 1988). Aerial surveys of the loosely colonial, tree-nesting AWbV have not been conducted. The widespread distribution of nests within AWbV colonies (as observed during the ground survey) was considered suited to an aerial survey, as the required areas could be surveyed more easily than from the ground.

The aerial survey was carried out using a microlight aircraft in a delta-wing and open trike configuration, with the observer sitting directly behind the pilot. Airspeed ranged between 45 and 110 km/h and was dependent on wind speed. Apart from survey areas predetermined from ground surveys, nests were also searched for during flights between the landing strips and the survey areas.

A series of flight transects were established across survey areas using known landmarks (such as fence lines, powerlines, farm tracks, water points, roads or railway lines) as references. Each survey area consisted of an entire breeding colony, plus any surrounding areas that contained *Acacia* woodland or trees and the aerial survey aimed to count all active nests in the survey area. Larger colonies that could not be surveyed in one day (due to weather conditions) were counted in sections delineated by known landmarks. To avoid double-counting, survey areas were divided into pre-determined transect widths that were measured using a marked gauging stick, which

Table 1. Viewing distances (m) from either side of microlight aircraft under different conditions during aerial surveys of African white-backed vulture breeding colonies, greater Kimberley area, South Africa.

Flight path		Wind direction		
↑		↓	↑	↑ ↑
Sun direction	↓	100 : 100	100 : 100	0 : 100
	↑	200 : 200	100 : 100	0 : 200
	→	100 : 300	100 : 200	0 : 200
	←	300 : 100	200 : 100	0 : 100
	↘	100 : 300	100 : 200	0 : 200
	↙	300 : 100	200 : 100	0 : 100
	↖	200 : 200	200 : 100	0 : 100
	↗	200 : 200	100 : 200	0 : 200

extended out either side of the microlight. This was fixed at 60 cm below eye level and active vulture nests were recorded within each transect width.

The total width of each individual transect in a series was varied according to the position of the sun and wind direction. On transects with a strong tailwind, counts were made from only one side of the microlight. This was a result of the significantly higher air speed and a subsequent reduction in the ability to count nests (referred to as 'viewability'). Return transects headed into the wind were slower and nests were counted on each side of the microlight. The width of transects on the ground ranged from 200–400 m. In ideal conditions (heading into the wind and away from the sun), nests were counted on each side of the microlight to a distance of 200 m (400 m total transect width). Under any conditions, viewing distance from one side of the microlight was limited to an absolute maximum of 300 m of total transect width. Viewing distances from the microlight under different conditions are shown in Table 1.

Wind direction and sun position also determined the direction of transects. Crosswind transects were not possible due to 'crabbing' (sideways movement) of the microlight. This disrupted accurate measurement of the transect width and direction. In windless conditions, transects were flown directly into or away from the sun. Turbulence caused by thermals disrupted the survey flight patterns. Aerial surveys were therefore conducted preferentially during early morning, usually from 08:00–11:00, before land-surface temperatures increased and thermal activity was pronounced. Dependent upon thermal conditions, afternoon surveys were also possible between 14:00 and 16:00.

During reconnaissance flights for the aerial survey, a survey altitude of 110 m a.g.l. (above ground level – maintained using a radar altimeter) was determined to be effective. Below this height, nesting vultures were more easily startled and would leave the nest, whereas above this height viewability was reduced.

During ground surveys, nests were only recorded as active if vultures were observed incubating or brooding, or if a chick was heard in the nest. During aerial surveys nests were recorded as active if vultures were incubating, if there was an egg in the nest with an adult in attendance (*i.e.* not incubating), or if a nestling was present.

Nesting densities

The boundaries of each colony were established using landmarks identified during both the ground and aerial surveys. Once transposed onto the 1:50 000 topocadastral map sheets, this information was scanned and digitized into the GIS package IDRISI version I32.2 (Clark Labs 2001).

Table 2. The number of active African white-backed vulture nests located on properties in the greater Kimberley area, South Africa.

Colony name	Property names in colony	Ground survey count	Aerial survey count	Approximate area (km^2)	Nest density ($nests/km^2$)
Dronfield	Dronfield, Inglewood, Loskop, Samaria, Tarentaalrand	43	28	135	0.32
Riet River	Doornlaagte, Eureka, Kookfontein, Rietfontein, Schutsekama, Valbosch Pan	28	69	120	0.58
Rivermead	Rivermead, Nooitgedacht	12	24	50	0.48
Susanna	Benfontein, Kameelpan, Susanna, Uitkyk 2	22	79	130	0.61
Paardeberg	Brakpan, Paardeberg, Uitkyk	12	27	66	0.41
Secretarius	Secretarius	2	Not surveyed	5	0.40
Total		119	227	506	0.46

The areas covered by each colony were subsequently calculated using the standard area analysis function. Nesting densities were determined from this calculated area.

RESULTS

During the ground surveys, six AWbV breeding colonies were located on 21 properties (Table 2). A total of 227 active nests were counted by microlight and seven additional nests, *i.e.* not counted during the microlight survey, were counted from the ground. Nine nests were recorded with chicks during the ground survey. No chicks were seen during the aerial survey, although eggs were observed in several nests.

The Secretarius colony and the property 'Loskop' in the Dronfield colony were not surveyed from the air. The two nests recorded at Secretarius resulted from an extensive search of an old breeding colony (active approximately eight years previously; S. Cox, pers. comm.), and were an unexpected discovery. On the property 'Loskop', five nests were counted from the ground, but it was estimated that at least another five active nests were present.

A conservative estimate is that there were at least 240 pairs breeding in the study area during 2001. Using an estimate of 0.35 additional immatures and non-breeding adults per breeding adult (Mundy *et al.* 1992), there are estimated to be 650 birds in total across all six colonies (Fig. 1).

Nest densities range from $0.32/km^2$ to $0.61/km^2$ across the colonies, with an average density of $0.46/km^2$. The calculated total area covered by the colonies (506 km^2) represents 12.7% of the original study area of approximately 4000 km^2.

DISCUSSION

Survey technique

Despite the apparent conspicuousness of an AWbV nest, the observers agreed that, contrary to pre-survey expectations, game animals were more easily spotted than vulture nests. This was surprising, given that with an adult vulture on a nest the effective size of the object in view is nearly 1 m^2. Nests are also stationary and generally quite different in colour to the tree canopy. This confirmed the need for a relatively slow and low-flying aircraft for accurate survey work.

The use of a microlight aircraft was warranted and considered advantageous over a small fixed-wing aircraft, primarily due to speed. Small fixed-wing aircraft cruise at speeds of 130–150 km/h, while under satisfactory conditions a microlight travels at less than half this speed.

Weather conditions impacted significantly on the aerial survey method. Thermal conditions were not suitable for flying transects with a microlight. Turbulence from thermals could result in increases or decreases in altitude of 50 m or more, which corresponded to an increase in transect width of 80–100 m, when using the fixed length gauging stick. In conjunction with the ideal survey months (June/July), the most satisfactory time for the microlight survey technique was mid-morning, before wind and thermal conditions detracted from transect accuracy.

Viewing distance from the microlight was fixed at a maximum of 300 m for two reasons. First, accurately identifying nests is difficult due to the distance involved. Second, canopies of *A. erioloba* nest trees are often significantly convex and vultures do not always nest at the apex of the tree. As a result, a nest beyond 300 m may be obscured from view by the canopy. In addition, AWbV nests are predominantly on the southern side of tree canopies (Murn 2001). Combined with the convex profile of some nest tree canopies, sun angle is an important factor that affects viewability. Once the sun is less than 20° above the horizon (approximately 16:30 at this latitude during July) viewability is compromised regardless of weather conditions.

AWbVs are not easily startled while nesting. They will often remain at their nest until a ground observer approaches within 20–30 m. Similarly, once reconnaissance flights had established an appropriate survey altitude, vultures were not disturbed from their nests. Therefore the possibility of double-counting due to disturbed vultures moving was eliminated. The minimal disturbance caused by the microlight to nesting birds is also the most likely explanation for the lack of chicks seen during aerial surveys.

Across all colonies, ground surveys covered significantly smaller areas than did aerial surveys. This explains the lower counts for ground surveys, except for the Dronfield colony. A larger proportion of time was spent at this colony during habitat and nest tree investigations (C. Murn, pers. obs.), which resulted in a higher number of nests being observed. In addition, a different team of observers surveyed this colony, possibly leading to a level of inter-observer bias. In any case, the low aerial survey count for this colony was unexpected and highlights the need to calibrate the aerial survey method with exhaustive ground surveys.

Population estimates

The estimate of 240 AWbV breeding pairs from this survey is more than double the estimate provided by Anderson & Maritz (1997) of 110 pairs in the Kimberley area and a maximum of 300 breeding pairs in the Northern Cape. The consequences of the totals obtained by this survey technique are significant.

If other reported colony sizes in the province are accurate, it is now possible that nearly 60% of AWbVs in the Northern Cape breed around Kimberley. This increases to 85% the proportion that breed in non-protected areas within the province. The greater Kimberley area may also contain up to 7% of the total population in South Africa, Lesotho and Swaziland (Anderson 2000). Furthermore, if this aerial survey has revealed that previous population totals were underestimates, it may be possible that the entire regional population is also an underestimate. Application of the aerial survey technique in other areas would enable this situation to be clarified. Areas outside South Africa, such as Botswana, where the size and distribution of the breeding population is largely unknown (*e.g.* Borello & Borello 1997), would also benefit from such surveys.

Even if regional population estimates are low, and AWbVs exist in higher numbers than currently suggested, there are still serious threats facing this species across the region (*e.g.* Anderson 1995; Anderson *et al.* 1999; Kruger 1999; Van Rooyen 2000). The impact of these threats may need further investigation. For example, rates of powerline mortalities in the Kimberley area recorded by Murn (2001) during an intensive farmer questionnaire survey were significantly higher than the nationally reported figures provided by Van Rooyen (2000). It is possible that, in addition to population figures, reported mortality rates for AWbVs across the region might also be underestimates.

The population estimate provided by this aerial survey provides important baseline data for future comparisons, in particular the detection of population trends. This is particularly important in the light of the recent population collapse of vultures in Asia and the possibility of the spread of an infectious disease to Africa (Anderson & Mundy 2000). Some of the AWbV breeding colonies in the Kimberley area (particularly the Dronfield colony) are well monitored. Given that this population faces similar threats to breeding populations elsewhere in the region (Murn 2001), it is possible that the Dronfield population would be a useful indicator of AWbV population trends in South Africa (and possibly southern Africa).

Nesting densities

Although the number of breeding pairs recorded at the Dronfield colony (43) is comparable to the figure of 47 provided by Anderson & Maritz (1997), the estimated nest density (0.32 nests/km^2) is lower than that of all other surveyed colonies. In addition, it was the only colony where the aerial survey returned a low count relative to the ground survey. This suggests that the population of the

Dronfield colony is larger than the size recorded during the aerial survey. It has also been larger in the past. Mundy (1982) related a figure (in 1978) for the Dronfield colony of 64 nesting pairs in a smaller area (58 km^2), a nest density of 1.1/km^2. A subsequent ground investigation of this colony during 2001 revealed a total of 74 nesting attempts (M.D. Anderson & A. Anthony, unpubl. data). Estimated nest density for the Dronfield colony thus increased to 0.55 nests/km^2, a value that is comparable to the other colonies in this survey.

The relatively high nest density for the Susanna colony (0.61 nests/km^2) is the result of two main features. First, a dense congregation of 16 nests was recorded in a patch of woodland of approximately 200 ha. Second, unlike the other colonies, AWbVs breeding at the Susanna colony also utilize *A. tortilis* as a nesting tree. The distribution of these trees is restricted within the colony boundaries, and has resulted in a second tight cluster of nests.

Although nest numbers are higher than previous estimates, nest site densities are lower than previous observations at the Dronfield colony (Forrester 1967; Mundy 1982). It is therefore possible that the area covered by this colony has increased over recent years. In other parts of their range, AWbV also utilize riverine trees. Nest densities in these linear-type colonies have been reported as high as 1.7 nests/km^2 (Monadjem 2001) and are also higher than the densities recorded during this survey. The AWbV does not utilize riverine habitat, such as along the Vaal and Riet rivers, in the Kimberley area.

These data suggest that the AWbV breeding habitat in the Kimberley area is not at capacity and that there is room for the population to increase in number. In addition, it has been hypothesised that there are sufficient food resources in the area for a continued increase in vulture numbers (Murn 2001). Although it is possible that other factors (such as unnatural mortality causes) may be affecting population growth, there is some evidence that the AWbV population is expanding. The re-establishment of Secretarius colony, as well as the foundation and growth of the Paardeberg colony from zero to at least 27 nesting pairs in the last five years, appears to reflect this expansion.

Recommendations

The use of microlight aircraft to survey the vulture breeding colonies proved a useful technique. Using this method, labour and time costs associated with exhaustive ground surveys can be avoided, and large areas can be covered with relative ease. Despite this, in order to calibrate and/or validate this initial aerial survey, it is recommended that exhaustive ground surveys of breeding colonies be conducted. Once calibrated, application of the microlight survey technique to assess populations of AWbV colonies in other parts of southern Africa (and particularly Botswana) is also recommended.

ACKNOWLEDGEMENTS

We thank the Vulture Study Group, Sasol, and Engen Petroleum – Inland Business Unit for sponsoring the microlight running costs. The Kimberley Microlight Club (pilots: Charles Ridgard, Koos Louw and Piet Becker) and Andrew and John Mackenzie assisted with the aerial survey. Guy Castley provided advice on the survey technique. De Beers Consolidated Mines allowed access to their properties, as did several other landowners in the Kimberley area. Mr van der Merwe (Al Drie Boedery) and Mr le Roux (Rooipan) are thanked for landing permission during the survey. Peter Mundy, Guy Castley and two anonymous referees commented on the manuscript. Tania Anderson, Eddie MacFarlane, Julius Koen, Graham Main, Werner Sinclair and Corné Anderson have been very supportive of our vulture research in the Kimberley area over the years. De Beers Consolidated Mines' Geology Division (now De Beers' Global Geological Services Division) provided a vehicle and accommodation during C.M.'s stay in Kimberley. We are particularly appreciative of the support received from Mike Lain, Jock Robey, Stuart Brown and Philip and Heleen Mills.

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