Comparison of nectar foraging efficiency in the Cape honeybee, *Apis mellifera capensis* Escholtz, and the African honeybee, *Apis mellifera adansonii* Latreille, in the western Cape Province

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Colonies of African honeybees have significantly ($p < 0,05$) more unsuccessful foragers than colonies of Cape honeybees, while Cape colonies have significantly ($p < 0,02$) more foragers returning with nectar. No significant difference was observed in the numbers of returning pollen gatherers or foragers carrying both pollen and nectar. Nectar foragers of Cape honeybees return with significantly larger volumes of nectar ($p < 0,001$) than nectar foragers of the African race. The nectar concentrations showed no significant difference. No significant difference was observed in the mass of pollen carried by returning pollen gatherers. The Cape honeybee foragers returning with both pollen and nectar had significantly larger volumes ($p < 0,05$) of nectar and larger loads of pollen ($p < 0,05$). The nectar concentrations showed no significant difference. Colonies of African honeybees showed a mean mass loss of 3,37 kg while colonies of Cape honeybees showed a mean mass gain of 1,88 kg over the experimental period of 78 days. The hypothesis has been advanced that these differences reflect adaptations in the Cape honeybee to a more temperate environment. It is also suggested that the distribution of the African honeybee in southern Africa and South America is limited to an inability to provision the nest with sufficient energy to withstand the temperate winter conditions prevailing in these latitudes.

Swerms van die Afrika-heuningby het betekenisvol ($p < 0,05$) meer onsuksesvolle kossoekers as swerms van die Kaapse heuningby, terwyl Kaapse swerms betekenisvol ($p < 0,02$) meer kossoekers het wat terugkeer met nektar. Nektarversamelaars van die Kaapse heuningby kom terug met meer betekenisvolle hoeveelhede nektar ($p < 0,001$) in vergelyking met nektarversamelaars van die Afrika-ras. Die nektarkonsentrasie wys geen betekenisvolle verskille nie. Geen betekenisvolle verskil was opmerkbaar in die massa van terugkerende stuifmeelversamelaars nie. Die terugkerende Kaapse versamelaarheuningby wat sowel stuifmeel as nektar dra het betekenisvol groter volumes ($p < 0,05$) nektar en groter massas stuifmeel gehad ($p < 0,05$). Die nektarkonsentrasie het geen betekenisvolle verskil gewys nie. Swerms van die Afrika-heuningby het 'n gemiddelde massaverlies van 3,37 kg getoon terwyl swerms van die Kaapse heuningby 'n gemiddelde massatoename van 1,88 kg oor die eksperimentele periode van 78 dae getoon het. Daar is tot die gevolgtrekking gekom dat die Kaapse heuningby baie meer aanpasbaar is in 'n gematigde omgewing. Daar is ook voorgestel dat die verspreiding van die Afrika-heuningby in Suid-Afrika en Suid-Amerika beperk is as gevolg van die onbevoegdheid van die swerm om genoeg energie te voorsien om weerstand te bied teen die wintertoestande.

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The possible climatic limitation in the spread of the African honeybee points to some possible energetic difference between the African and other more temperate races of honeybee. Studies on differences in colony metabolism and thermoregulation between south-western Cape and African honeybees have demonstrated that at moderately low environmental temperatures the Cape honeybee colony shows considerably lower energy expenditure than the African subspecies and this adaptation is thought to enable the Cape honeybee to survive the cold wet winters of the Cape (W-Worswick 1987).

In South America it has been demonstrated that Africanized and European honeybees respond differently to nectar resources. European bees had significantly higher numbers of foragers in the field and greater success in obtaining a nectar load (Rinderer Bolten, Collins & Harbo 1984). These studies suggest that the African honeybee shows adaptations in energy collection and expenditure that possibly restrict its southern geographical limits in both South America and in South Africa.

This study set out to answer the following questions. Firstly, do bees of the two geographical races show differences in the volume of nectar they collect? Secondly, do the two races collect nectar of different concentrations? Thirdly, do the two geographical races show differences in the amount of pollen they collect? Fourthly, is the energy gathering success rate of the two geographical races similar?

Materials and Methods

The experiment was conducted 20 km south of Cape Town, South Africa. The vegetation in the foraging area, accessible to the bees, contained large tracts of mixed *Eucalyptus* and mountain fynbos. The experiments were carried out between March and June 1985.

Colonies of *A. m. adansonii* were obtained from Robben Island where the Department of Agriculture maintained an isolated African bee breeding sanctuary. Feral colonies of *A. m. capensis* were collected and hived from around the environs of Cape Town. Two months before observations began, four colonies of each subspecies were transferred from five frame nuc. boxes into standard Langstroth brood chambers and given a further five frames of drawn comb and then transported to the experimental site. The colonies were transported back to the laboratory for weighing on 20 March 1985 at the beginning of the experiment and again on 6 May 1985.

At 11h00 on each observation day all the entrance holes of the hives were blocked and 20 returning foragers were collected from each hive entrance and killed with chloroform. The bees, once immobilized, were quickly transferred into vials and stored on ice. They were then immediately transported back to the laboratory where their nectar was expelled (Gary & Lorenzen 1976) and collected in a 100 μl micropipette. The volume was then determined to the nearest 0,5 μl and the sugar concentration was read using a hand refractometer. All the pollen was carefully removed from the hind legs and the mass determined to the nearest 0,01 mg. These measurements enabled the estimation of numbers of nectar gatherers, pollen gatherers, and of foragers carrying both nectar and pollen. Bees were collected from the colonies approximately once a week for eight consecutive weeks.

On each experimental day the 80 foragers sampled of the two different races were grouped into one of the following four categories: nectar foragers, pollen foragers, both nectar and pollen foragers, and finally those unsuccessful in obtaining a load. The number of individuals in each of these categories for the two races was analysed using the chi-square test. The comparative nectar volume, concentration, and pollen mass of each of the three successful foraging categories were analysed using factorial analysis of variance (Snedecor & Cochrane 1967). Finally, nectar volume, concentration, and pollen mass for all returning foragers were compared using the same technique.

Results and Discussion

In its natural environment the ecology of the honeybee colony is quite different to the situation when it inhabits a beekeeper's hive. The beekeeper requires a large non-swarming colony capable of stockpiling a vast quantity of honey, more than the colony would actually need itself, while the feral colony balances its energies between colony reproduction and honey storage. These two types of colonies differ strikingly in patterns of survival (Seeley 1983). Wild colonies in temperate latitudes face a far harsher existence than their domesticated counterparts. Studies in temperate latitudes have estimated that in their first year 75% of feral colonies starve. However, if the colony survives this critical period, mortality drops to about 20% per year (Seeley 1983). Death is almost always during winter and is due to starvation. The principal ecological challenge facing honeybee colonies in temperate conditions is provisioning the nest for their survival during winter.

Provisioning the nest with sufficient honey stores to overwinter is achieved by several elements of honeybee social behaviour, most important of which is the communication and recruitment of other foragers to an energy rich nectar source. Just as the environmental conditions between the tropics and the more temperate regions differ, so too will the colonies balance between energy storage and reproduction. Consequently the adaptations in provisioning the nest and ultimately foraging behaviour between these areas will be different.

Foraging success

Table 1 shows the deployment of foragers of the two subspecies over the whole experiment. The most significant observation is the difference in the success rate of foragers of the two geographical races, the Cape bee having a higher proportion ($p < 0,05$) of successful foragers with fewer than 4% of returning foragers being unsuccessful. In the African bee approximately 20% of all returning foragers were unsuccessful in obtaining a load of either pollen or nectar.

The Cape bee had a significantly higher proportion ($p < 0,02$) of nectar foragers than the African subspecies. There was no significant difference in the number of returning pollen gatherers or foragers carrying both pollen and nectar to the hives of each of the subspecies.

Similar studies of the nectar foraging characteristics of European and Africanized honeybees conducted in South America have shown similar results (Rinderer *et al.* 1984). In those studies it was found that the European honeybees were more successful foragers than the Africanized bee but that their success rate tended to be either low or high and they attributed this to a foraging strategy highly dependent on recruitment and group foraging. High success rates would occur when a nectar source has been located and efficient recruitment had occurred. Low success rates of foragers would occur when scouts find only a few nectar sources not of sufficient value to stimulate recruitment (Rinderer *et al.* 1984). In the present study this variation in success rate was not evident. On all the eight sample days the percentage of unsuccessful Cape honeybee foragers was consistently low, ranging from 0%–8,3%, while those of the African honeybee ranged from 10,1%–26,8%. The lack of variation in the present study when compared with the results of previous trials (Rinderer *et al.* 1984) might be due to the presence of a more stable and reliable nectar source in the *Eucalyptus* forests in the

Table 1 The activities of returning foragers of the two geographical types of honeybees, *Apis mellifera capensis* and *Apis mellifera adansonii*

Foraging category	Geographical type	$\bar{x}$	s	χ^2	p
Unsuccessful	*capensis*	2,75	2,33	4,370	0,0518
	adansonii	16,25	4,37		
Nectar forager	*capensis*	36,13	17,95	16,276	0,0227
	adansonii	31,38	8,79		
Pollen forager	*capensis*	16,63	10,44	10,104	0,1828
	adansonii	20,13	6,35		
Pollen & Nectar	*capensis*	25,50	18,63	10,955	0,1406
	adansonii	12,75	7,40		

present study. The significantly higher foraging success rate of Cape honeybees would mean a substantially larger energy store at the end of the day when compared with an African colony of similar size.

Nectar gatherers

As stated above the African honeybee colonies had significantly fewer nectar foragers in the field. There was no significant difference in the concentration of the nectar collected by nectar gatherers of the two subspecies. There were, however, very significant differences in the volumes collected. On all the experimental days Cape honeybees carried significantly more ($p < 0{,}001$) nectar than the African subspecies.

Figure 1 illustrates the difference in volumes of nectar carried by nectar foragers. On each experimental day the average Cape nectar gatherer was collecting approximately 7 μl more nectar than the average African nectar gatherer. This volume represents between 30 and 50% larger nectar loads carried by Cape honeybees.

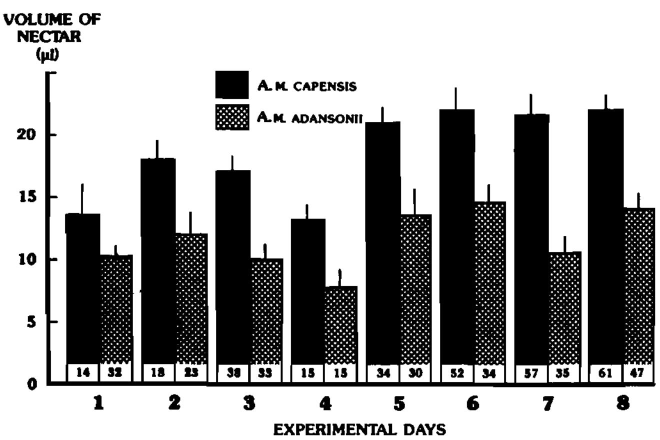

Figure 1 Volumes of nectar collected by nectar foragers of the two geographical races of honeybee. Nectar foragers of *A. m. capensis* collected a significantly larger volume ($p < 0{,}001$) than nectar foragers of *A. m. adansonii*.

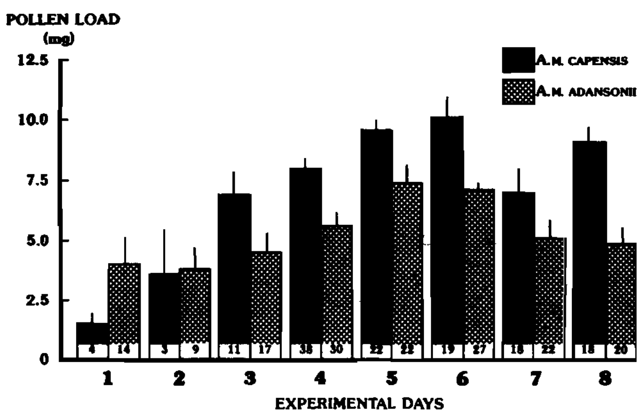

Figure 2 Pollen mass collected by pollen gatherers of the two races of honeybee. No significant differences in the pollen masses of pollen gatherers was observed.

Pollen gatherers

Both subspecies had approximately the same number of successful pollen gatherers returning to the hive and measurements of the mass of pollen carried by these individuals showed no significant differences in their mass. Figure 2 illustrates the comparative pollen loads carried by returning pollen gatherers.

Pollen and nectar gatherers

As shown in Table 1 there was no significant difference between the numbers of foragers carrying both pollen and nectar in the two subspecies. The Cape bee carried significantly ($p < 0{,}05$) larger volumes than the African bee but there was no observed significant difference in the respective concentrations (see Figure 3a). Examination of the pollen masses of this group of foragers showed that the Cape bee carried significantly ($p < 0{,}05$) larger masses of pollen compared with the African honeybee (Figure 3b).

If the results of all returning foragers are pooled and unsuccessful foragers are not ignored by grouping foragers into categories, a more realistic approach to the energy balance is produced. Figures 4a & 4b illustrate the nectar volume and pollen mass collected by all returning foragers. The data show that for each forager in the field the Cape colony is collecting approximately

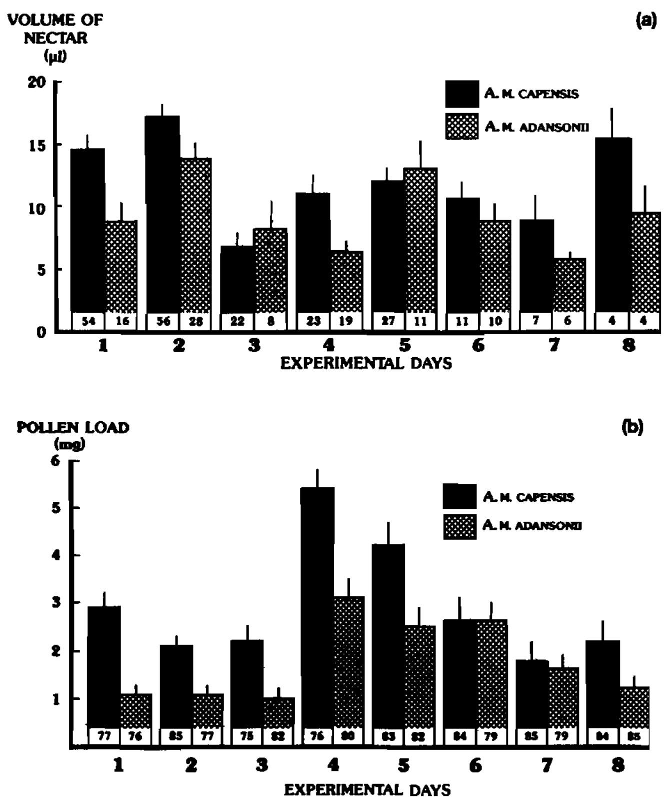

Figure 3 (a) Volume of nectar collected by both nectar and pollen gatherers. *A. m. capensis* foragers in this category collected significantly larger volumes of nectar ($p < 0{,}05$) than foragers of *A. m. adansonii*. Figure 3(b) Pollen loads of foragers carrying both pollen and nectar. *A. m. capensis* foragers in this category collected significantly more pollen by mass ($p < 0{,}05$) than *A. m. adansonii*.

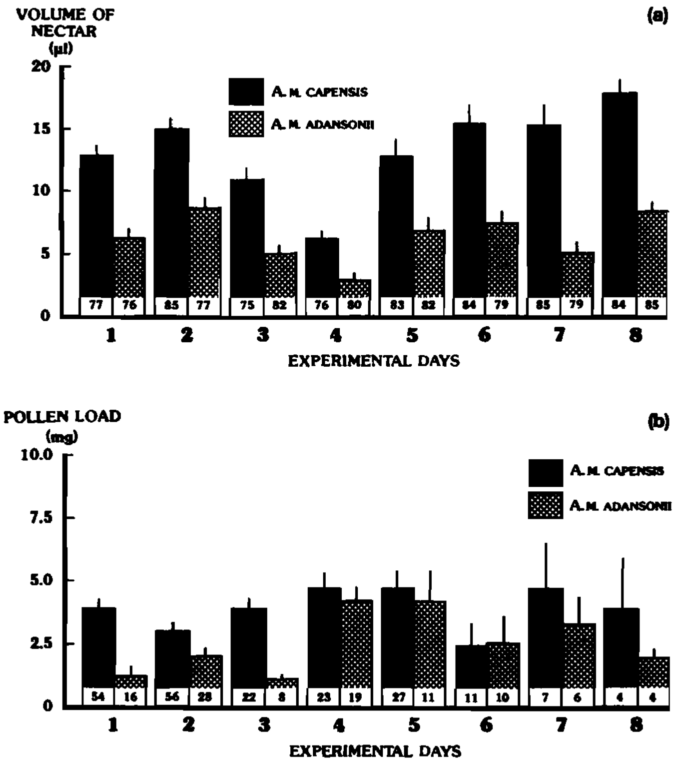

Figure 4 (a) Nectar volume collected by all returning foragers sampled. *A. m. capensis* colonies collected significantly more nectar ($p < 0{,}019$) and significantly ($p < 0{,}05$) more pollen (Figure 4(b)) per forager deployed in the field than colonies of *A. m. adansonii*.

double the volume of nectar and almost twice the mass of pollen.

Comparative colony mass gain

At the beginning and the end of the experiment the mass of each colony was measured and the difference in the mass of the colony was recorded over the entire period which spanned 78 days. The results are presented in Table 2. Unfortunately one of the African colonies was destroyed by ants towards the end of the experiment.

From Table 2 it was calculated that the Cape honeybee colonies had a mean mass gain of 1,86 kg ($s = 0{,}63$) per colony over the experimental period of 78 days. The African colonies on the other hand had a mass loss of 3,32 kg ($s = 2{,}32$) per colony.

The foraging differences found in this study suggest that the races of honeybees are genetically adapted to foraging under climatic and resource conditions typical of their respective environments. Additionally, the data suggest that colonies of Cape honeybee are more

Table 2 Comparative colony mass gain or loss in kg during the experimental period 20/3/85–5/6/86

	1	2	3	4	Mean
A.m.adansonii					
20–3–85	27,80	30,35	28,50	31,45	
05–6–85	27,70	25,80	*	26,45	
Mass loss	–0,10	–4,55		–5,00	$\bar{x} = -3{,}22$
A.m.capensis					
20–3–85	27,94	25,36	26,26	30,10	
05–6–85	30,60	26,40	28,50	31,60	
Mass gain	2,66	1,04	2,24	1,50	$\bar{x} = 1{,}86$

*Colony destroyed by ants before final weighing.

efficient foragers than African honeybee colonies under the conditions of the experiment. I suggest that this difference is due to an adaptation in the Cape bee to a more temperate environment when compared to the African bee. It is also probable that the limited southern distribution of the African honeybee in South Africa and South America is due to its inability to provision the nest with sufficient energy to survive the more prolonged winter conditions prevailing in these latitudes.

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