give preferential treatment to the ergatoids.

What selective pressures could cause the queens to adopt a worker-like appearance? Haskins and Haskins (1950) suggested that ergatoids are often found in "those forms in which wing-muscle degeneration does not occur and where foraging of the colony-founding queen is the rule". This may partly explain the frequent occurrence of ergatoids in the Ponerinae. The partially-claustral mode of colony foundation is a precarious strategy which is successful only within a certain range of ecological conditions (see 7.2.). The more advanced fully-claustral mode was derived through increased divergence in the size of queens and workers and the subsequent increased utilization of wing muscles by the lone foundress. An alternative evolutionary progression appears to have been loss of wings and reduction in thoracic musculature, ie. the ergatoid strategy. Haskins (1970) presents evidence that in Myrmecia, the presence of wings is not always advantageous. Wingless and brachypterous females sometimes coexist with the normal forms, and they seem to be equally successful during colony foundation. The loss of wings in many ponerine ants affects the pattern of dispersal but not the partially-claustral mode of colony foundation. This suggests the nature of the selective advantages associated with the ergatoid modification. There may be a high mortality during aerial dispersal, or it may be safer to be mated near the nest. A change to colony fission may also be implicated, but the pattern of colony reproduction in species with ergatoids is very poorly understood. Ergatoids are often found in socially-parasitic myrmicines (Wilson 1971), and a consideration of their reproductive behaviour may indicate some of the evolutionary pressures involved with the loss of wings.

Where either colony foundation by winged queens or by ergatoid queens was unsuccessful, it is suggested that breeding workers assumed the reproductive role.

7.4. Transition from queenright to worker breeding system

The substitution of the queen caste by mated workers was made possible in the ponerines through a number of preadaptations. Workers in the phylogenetically-primitive formicid groups have retained functional ovaries and a spermatheca. In contrast, in the higher ants, the workers have often lost the ability to produce diploid eggs. The morphological differentiation between queen and workers is slight in the ponerines (Haskins 1970; Odontomachus, Brown 1976). Trophallaxis does not exist between ponerine adults, and this has two important consequences. Workers appropriate the food that is brought into the nests for themselves only and are thus able to accumulate fat reserves; this is then available if the ovaries become active. This is analogous to the situation in orphaned colonies of many species, where workers are able to produce male or trophic eggs, possibly because they no longer have to regurgitate to the queen. Absence of trophallaxis also implies that the queen has to ingest raw food, which limits her rate of egg production. The relatively small colony size may be an effect of the low fecundity of the queens. Colombel (1970) (in Brown 1976) estimated that a mature queen of Odontomachus troglodytes lays 2,5 eggs per day. The lack of a drastic divergence between queens and workers makes it more feasible for the latter to replace the queens. In addition, workers possess a pygidial gland, and the signal produced from it may enable the males to recognize suitable sexual mates (Chapter 6). At a functional level, worker reproduction necessitates colony reproduction through fission, and thus appropriate fragmentation mechanisms are required, eg. O. berthoudi has polydomous colonies, and Ward (1981a) observed frequent nest emigrations in the Rhytidoponera impressa group.

What was the reproductive system in those ancestral species which gave rise to breeding workers? Ward's (1981b, 1983) data on the Rhytidoponera impressa group suggest that evolutionary

changes followed path (b) in Figure 13; winged queens and gamergates occur in the same species (although they never coexist in one colony). I suggest an alternative pathway, which would involve a two-step process via path (a) and (c). Thus the hypothetical lost queen may have been ergatoid in some cases.

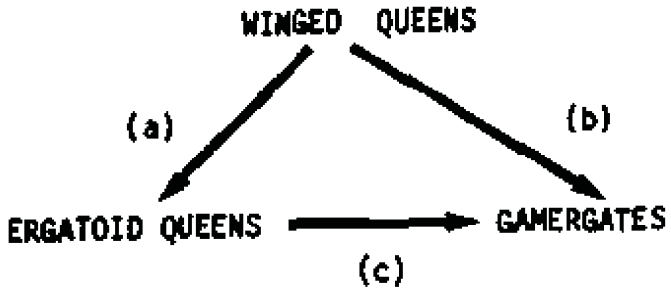

Figure 13 Hypothetical scheme of evolutionary changes leading to the disappearance of winged queens.

As was shown in 7.3., the change in queen morphology which occurred through the loss of wings (path (a), Figure 13) is a strategy very distinct from that of worker reproduction. Was the ergatoid strategy successful? Not many extant ponerine species have ergatoids, and there may be more species in fact that have gamergates. Loss of wings might be adaptive only under a narrow range of environmental conditions, and if these change the species are in an evolutionary cul-de-sac. The winged condition cannot be re-evolved, and worker reproduction may be the only solution.

The two alternative evolutionary schemes need to be considered in view of the necessary changes in male behaviour. The pattern of male dispersal must at all times be coadapted with the activities of the female partner. Many formicids disperse and mate on highly-coordinated mass nuptial flights, which act as an orientation cue for the sexuals from different colonies to meet. This mode of dispersal is however an advanced trait which

is not exhibited in the majority of queenright ponerine species (reviewed by Haskins 1970). I have witnessed the synchronized exit of male and female winged reproductives of the queenright Paltothyreus tarsatus in Mkuzi Reserve; this occurred at the end of a sunny morning following the first summer rains. The virgin queens landed singly on bushes and other vegetation. Individual females then presumably released a sex pheromone because flying males soon appeared and were observed to mate with them. This is similar to the behaviour in Amblyopone pallipes (Haskins 1978). Thus the males fly around searching for individual virgins, and the chances of success are enhanced because the alates of both sexes are active simultaneously.

In species with ergatoids the mating activities occur near the nests. Males locate their mates on the ground, and the latter seldom disperse very far from their nests. Males of Leptogenys use ground-laid recruitment trails to locate ergatoids (Maschwitz and Muhlenberg 1975). There is no reason to assume that the ergatoids (still a distinct reproductive caste, see 7.3.) do not leave their nests together with the males. The synchronization is probably mediated through the release of mandibular gland secretions by the males (Buschinger 1975). As a result males search for ergatoids when these are out of their nests and releasing sex attractants. The next step in the evolutionary series occurs when males use trails to orientate to foreign nests (as in Megaponera foetens, Longhurst and Howse 1979). Thus the male strategy now consists of finding nests, not individuals anymore. This switch in male behaviour has significant consequences for it brings the sexually-mature males in contact with the workers, a necessary prerequisite for worker mating.

In those species where the queen caste has disappeared, suitable workers are mated inside or in the vicinity of their nests. In O. berthoudi copulation occurs inside the nests, and this may suggest that they were derived from an ancestor with ergatoid reproductives. In Rhytidoponera metallica and R. chalybaea (Holldobler and Haskins 1977, Ward 1981b), males copulate with workers outside the nest entrances, and this may be

related to the occasional presence of winged queens in these species (Whelden 1960, Ward 1981b). In R. chalybaea the virgin queens and the males leave the nests together. This may be associated (as in other Formicids) with the swarm of a large number of workers which mill around the nest entrances. These workers are of different ages and thus males can come across those that are sexually-attractive, again a prerequisite for worker reproduction.

7.5. Why have queens not re-evolved?

Crozier (1982) has pointed out that the evolutionary expectation in those species of Rhytidoponera where queens have been replaced by a "coterie of mated workers" is that queens should re-evolve. This has not happened in Ophthalmopone berthoudi (see 3.3.2.), where there is an obvious lack of specialization in the reproductive individuals. No morphological differentiation between breeding and sterile workers was ever detected. There is a pair of ovaries with three short ovarioles, and the large yolky eggs are laid singly and at a slow rate. The simplicity of the ovaries of the egg-layers reflects their worker nature and dictates cooperative breeding by multiple fertile individuals. Why does a secondary differentiation within the worker caste not take place? This would lead to the evolution of a class of fecund egg-layers with elaborate ovaries and possibly smaller eggs, and these would mate to the exclusion of all others in the colony.

Ponerine workers can produce trophic or male eggs in species which have retained queens. Workers lay haploid eggs in the absence of the female parent in Rhytidoponera purpurea (Haskins and Whelden 1965), and male as well as trophic eggs are produced in Odontomachus troglodytes (Colombel 1972a). This oogenesis may have formed the basis for the production of fertilized eggs. In O. berthoudi, slight physiological modifications throughout the worker caste made the ovaries more suitable for this purpose. Ineffective breeding workers are eliminated by natural selection

since they produce few or no eggs. However there has been no further elaboration of the reproductive organs, and there has been no reduction in egg size. There is no selective advantage for large yolky reproductive eggs being laid in a social environment (in contrast to the solitary mutillids, where large eggs need to be laid). As there is no trophallaxis between workers and queens in this ponerine species, the reproductive investment of each breeding worker is restricted by the amount of food it can acquire. A decrease in the energy used per individual egg should be selected for, since with the same expenditure of material, fecundity could be increased. It may be that the large eggs of O. berthoudi are a legacy of a past trophic function, and that this design could not be subsequently changed. Other species of ponerines with gamergate reproductives have large eggs (Peeters unpublished data). The eggs in the queenless Pachycondyla krugeri are large (1,6 x 0,6 mm), while the congeneric, queenright P. wroughtoni (Forel) has typically small Formicid eggs. Large eggs may be an inherent characteristic of worker reproduction in the Ponerinae.

Genetic changes which increase the fecundity of individuals should sweep through a population rapidly, since reproductive success is the only possible basis for the operation of natural selection (Williams 1966). Fecundity in species exhibiting maternal care is limited not just by the energetic cost of egg production, but also by the time and energy invested in brood care. Indeed, the survival of the offspring to breeding age is essential for the realization of reproductive success. Mothers of eusocial insects do not carry the burden of feeding their own offspring, since all the ants in the colony contribute to the rearing of the larvae. Hence there are fewer constraints on the size of their reproductive investments. There are small differences in ovarian activity among breeding workers of O. berthoudi (see 3.3.2.). Thus some individuals do produce more daughters than the average and these daughters have the same chance of reaching breeding age as the offspring of other egg-layers. In spite of the destruction of gene combinations during meiosis and recombination, fitter genotypes should increase their

representation in the nest population. The lack of marked differences in fecundity between the workers in the queenless colonies of O. berthoudi might be traced, firstly, to the nature of the control of their reproductive division of labour, and secondly, to a stabilizing selection which prevents specialization in their unpartitioned nest populations.

The salient feature of eusociality is the presence of individuals that are obligatorily sterile. Usually only the reproductive caste has an opportunity to engage in sexual reproduction. The sterile workers are restricted to performing all the other activities essential for colony maintenance. In O. berthoudi however, all the workers have the potential to become reproductive, and thus they can fulfil both functions in the colony. Insemination determines whether they fall into one category or the other. It is the limited period of male activity that restricts the incidence of mating, and only those ants which are present and which are sexually attractive during February to March can copulate with the males. Diploid eggs are laid for most of the year, thus producing a continuous sequence of young individuals. Since the workers live for less than one year, the short period of sexual receptivity of many individuals does not coincide with the mating season. The breeding workers would be expected to synchronize the production of their own offspring with the activity of males, but they do not appear to be able to time their egg-laying (ie. by recognizing appropriate seasonal cues). As a consequence the timing of birth is not genetically controlled. The ants not born at the appropriate time of the year cannot become inseminated, and they remain non-reproductive. Thus a chance factor is introduced into the reproductive differentiation. Only a fraction of the sequentially-born daughters of "fitter" egg-layers can pass on their genes to the next generation. In addition, since the males cannot discriminate between potential mates on the basis of relative ovarian capabilities, all the workers of an appropriate age present in a nest have the same probability of becoming mated, including those with inferior ovarian apparatus. Since birth and mating are influenced by stochastic factors, many

superior gene combinations are lost. Furthermore, the less effective reproductive genotypes continue to circulate in the population because they are not selected against. Thus directional selection is expected to be ineffective in such a breeding system. It has not produced any changes over a great many generations. There may however also have been an opposing selective pressure acting against further reproductive specialization in the workers.

The genotype in O. berthoudi cannot become partitioned because of the nature of the control of oviposition, and this necessitates a "phenotypic compromise" between worker and reproductive attributes. The majority of the ants in these societies do not become reproductives, and they carry on their short lives as labourers. Colony survival is dependent on an effective worker force, especially since the breeding workers never leave the nests or participate in any of the maintenance activities. Ovarian improvements throughout the worker caste cannot be achieved at the expense of traits needed in non-reproductive colony members. In addition, if there are pleiotropic genes coding for fecundity or ovarian structure, these may have a negative effect on other characteristics needed for effective performance as a labourer. It is also possible that the mechanism of gene expression responsible for caste differentiation could not be re-evolved in this species. Selective pressures operate on a common worker "genetic programme" which must be sufficiently plastic to produce two functionally-distinct types of individuals. Thus only limited specialization is possible because of the lack of genetic compartmentalization.

Secondary reproductive differentiation in the worker caste could occur if there were only one generation of workers per year, since directional selection would then be effective. It is however impossible within the constraints of an existing eusocial system. As a result of the overlap of generations only a small sample of the workers can become mated. The social alterations exhibited by O. berthoudi were sufficient to enable continued survival in a particular environment. Since the

system works, directional selection pressures on it are unsuccessful. Were local conditions to become sub-optimal, this species might become extinct if survival were conditional on the development of a more efficient group of breeding workers.

These considerations suggest what the cardinal features of the evolution of a sterile caste in proto-formicid societies may have been. Haplodiploidy enables control of the sex ratio. While the timing and extent of haploid egg production were restricted, the production of female individuals was increased and staggered over the year. This gradually prevented many females from participating in sexual reproduction and hence forced them into the role of non-reproductive nestmates. Thus kin selection or queen oppression may not be responsible for the origin of castes with different reproductive potentials. Mechanistic explanations (Crewe 1982b) based on life history details can explain the control of the reproductive division of labour in O. berthoudi. They may similarly account for many enigmas surrounding the evolution of eusociality.

Crozier (1982) raised the question of what holds colonies of Rhytidoponera together in view of their very low intra-colony relatedness. This study on the biology of Ophthalmopone berthoudi indicates that colony odour is a fundamental aspect of eusocial organization. Despite the absence of the queen caste and a predicted low kinship within the colony, nestmate recognition maintains the social integrity of a group of workers. The viability of this eusocial alternative suggests that a reconsideration of some of the traditional views on the role of queens in the regulation of colonial life is timely.

APPENDIX A

Partial transcript from a computer-generated print-out, listing the activities performed by different ants from colony (3a) during an observation session (eg. 09A); repetitions and redundancies have been eliminated. First entry refers to the ants' colony ($) and identity code, second entry to the activity observed, third entry to the nest in which active. Fourth and fifth entries are used when adults, brood or termites were transferred between nests; the former denotes the nest of destination and the latter the identity of marked recruits (when these were unmarked, it is indicated by XXX). The various activity codes are as follows: INS= found inside nest; ABO= unspecified above ground activity; EXC= excavating; CLE= nest sanitation; REC, EGG, LAR, COC, TER= adult, egg, larva, cocoon and termite transfer respectively; WAK= walking between nests; FOR= foraging; CAR= carried between nests. The location of the various nests is given in Figure 5; WWW refers to unknown above ground location.

DATA FOR DAY 09A

$99	ABO	(Q)		
$99	ABO	(P)		
$101	ABO	(Q)		
$103	ABO	(P)		
$102	ABO	(P)		
$107	ABO	(P)		
$115	FOR	(Q)		
$114	FOR	(P)		
$117	ABO	(R)		
$117	CAR	(R)	(P)	$92
$117	ABO	(P)		
$117	WAK	(P)	(R)	
$117	CLE	(R)		
$117	CLE	(P)		
$118	FOR	(P)		
$33	ABO	(Q)		
$33	ABO	(P)		
$35	FOR	(Q)		
$38	FOR	(P)		
$39	ABO	(Q)		
$39	ABO	(S)		

$45	FOR	(Q)		
$45	TER	(Q)	(P)	
$36	LAR	(P)	(S)	
$30	ABO	(S)		
$30	ABO	(P)		
$28	CLE	(Q)		
$10	LAR	(P)	(S)	
$10	REC	(P)	(S)	XXX
$10	REC	(P)	(S)	$157
$10	CLE	(S)		
$11	CLE	(P)		
$11	CAR	(P)	(S)	
$15	ABO	(P)		
$21	FOR	(S)		
$66	ABO	(P)		
$63	CLE	(P)		
$62	ABO	(P)		
$61	CLE	(P)		
$57	ABO	(P)		
$55	ABO	(S)		
$56	ABO	(P)		
$53	ABO	(R)		
$53	LAR	(P)	(R)	
$53	CLE	(P)		
$51	ABO	(P)		
$72	TER	(P)	(R)	
$75	FOR	(P)		
$74	CLE	(P)		
$92	REC	(R)	(P)	$117
$88	FOR	(P)		
$88	ABO	(Q)		
$118	FOR	(P)		
$125	COC	(Q)	(P)	
$125	WAK	(P)	(S)	
$126	INS	(Q)		
$130	WAK	(P)	(Q)	
$132	ABO	(P)		
$132	LAR	WWW	(Q)	
$136	ABO	(P)		
$142	WAK	(Q)	(P)	
$147	CAR	(P)	(S)	$208
$149	INS	(Q)		
$150	LAR	(P)	(R)	
$151	ABO	(P)		
$161	LAR	(P)	(S)	
$189	CLE	(P)		
$189	COC	(P)	(Q)	
$158	INS	(Q)		
$198	ABO	(P)		
$205	CLE	(P)		
$208	EGG	(P)	(S)	
$186	INS	(Q)		

APPENDIX B

Partial transcript from a computer-generated print-out, summarizing the activities performed by different ants from colony (3a) over the entire October observation period. Entries correspond to those in Appendix A, except that the additional entry (no. 2) refers to the observation session (day; A= morning, P= afternoon) on which the activity was performed. Activity and nest codes are as in Appendix A.

$11	04P	EXC	(Q)		
	04P	CAR	(Q)	(P)	$70
	05A	ABO	(P)		
	05P	ABO	(P)		
	07A	CLE	(P)		
	07A	ABO	(S)		
	07P	ABO	(S)		
	08A	LAR	(P)	(S)	
	08P	CLE	(P)		
	09A	CLE	(P)		
	09A	CAR	(P)	(S)	$2
	12A	ABO	(S)		
	13A	REC	(S)	(P)	$203
	13A	REC	(S)	(P)	XXX
$12	03A	FOR	(P)		
	08A	INS	(P)		
	09P	ABO	(P)		
	11P	FOR	(P)		
	12A	FOR	(P)		
$13	not seen again				
$149	09A	INS	(Q)		
	12P	INS	(S)		
$150	07A	ABO	(P)		
	08A	ABO	(P)		
	08A	CLE	(R)		
	09A	LAR	(P)	(R)	
	09P	LAR	(P)	(R)	
	12A	ABO	(P)		
$151	07A	LAR	WWW	(R)	
	08A	ABO	(P)		
	09A	ABO	(P)		
	12A	ABO	(P)		

APPENDIX C

Soil temperatures at various times of the day during the month of April 1981. Measurements (in degrees Celsius) were taken on four separate days, with varying cloud cover. A digital thermometer with flexible thermocouples was used; these were placed in the following places: (A) on the surface and inside the entrance tunnel of an ant nest, (B) at three different depths in the soil profile.

(A) Time of day		Ground surface temperature	Temperature 10 cm down nest entrance
09h00		28,6	26,1
10h00		36,5	28,1
11h00		43,5	29,6
20h30		27,6	32,5
07h00		24,7	27,9
08h00		27,4	28,0
10h00	**	32,9	29,0
11h00		35,9	30,4
12h00		47,8	31,6
15h00		48,0	37,0
16h00		41,2	37,5

(B)	(- 10 cm)	(- 20 cm)	(-30 cm)
10H00	26,5	26,4	26,4
12H30	27,9	27,2	26,8

** air temperature: 27°C

APPENDIX D

Methods for gas chromatography

The mandibular gland secretions were extracted in pesticide residue-grade dichloromethane (Merck Chemicals, #6054). Either pairs of glands or single decapitated heads were used to prepare the extracts. The glands were dissected out of the heads of individual ants which had been immobilized by cooling, and were immediately placed in 10 µl of dichloromethane inside 0,2 ml crimp top vials.

The extracts were analyzed on a Carlo Erba Fractovap 2150 gas chromatograph equipped with a flame ionization detector and a 25m x 0,2mm Carbowax fused silica capillary column (Hewlett-Packard). The column was held at 40°C for 5 min. after sample injection, and was then programmed for an initial temperature rise to 165°C at 1,3°/min, and a further rise to 200°C at 39°/min. Helium was used as the carrier gas at a flow rate of 1,5 ml/min. The retention times of the extract components and the areas beneath the peaks were calculated by a Hewlett-Packard 3390A integrator connected to the gas chromatograph.

APPENDIX E

Rainfall figures (in mm) recorded at the Mantuma weather station in Mkuzi Reserve, during August-November 1981 and 1982. Only heavy downpours (sometimes representing rain over a few days) are included, together with the monthly totals.

Date	Daily rainfall	Monthly totals
31st August 1981	31	38
10th September 1981	25	102
11th September 1981	31	
12th September 1981	38	
10th October 1981	12	70
11th October 1981	48	
20th November 1981	60	128
August 1982	--	0
September 1982	--	6
21st October 1982	27	81
1st November 1982	30	67
7th November 1982	24	

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Social organization, breeding biology and the process of reproductive differentiation in *Ophthalmopone berthoudi* Forel, a ponerine ant

Christian Paul Peeters

ADDENDUM

Contents

Addition to p.11

There is strong evidence that the ants were not losing their marks with time:
(1) if it had occurred in the field, this would have resulted in some of the ants having unregistered colour combinations (unless the 2-4 marks on an individual flaked off simultaneously, which is very unlikely). On those occasions when nests were excavated at the end of an observation period, most of the marked ants were collected again (including some for which no activity data had been obtained). When colonies with marked ants were left in the field for a few weeks and even months, large numbers of individuals were re-collected with their previous colour combinations.
(2) it never occurred in laboratory colonies, where marked ants were observed continuously. There was frequent grooming of painted regions of the ants' bodies, without subsequent loss of the marks.
The cuticle in O. berthoudi is pubescent, and this explains why Humbrol paint adheres strongly to it. In contrast, marking of workers of Plectroctena conjugata was unsuccessful. Such ants have a shiny black cuticle, and it was found that the paint marks flaked off within days.

Addition to pp.47-48. Text should read as follows (p.47, line 26 onwards).

As the ants were released into the arena they soon met up and there were distinct antennations. The behaviour of the ants was monitored for 10-20 minutes, and in some tests the encounters were timed (Table 10a). The latter could not always be done precisely, especially since the beginning and end of an interaction are hard to determine. In addition there were sometimes two interactions occurring simultaneously, and then one had to be ignored. The intensity of the antennations could not be quantified, and thus additional descriptions are essential. A number of combinations of pairs of foragers were tested: (1) different nests from the same colony (n=3); (2) nests from different, but adjacent colonies (n=4)- in one of these it was suspected that colony fission had taken place in the recent past; (3) nests from different, distant colonies (n=3).

The initial interactions between workers from different colonies were characterized by prolonged and vigorous antennal "boxing" (Ward 1983); in subsequent encounters between the same individuals the duration of the antennation decreased (Table 10a). At the beginning of the tests there was no overt hostility between foreign ants, and they would walk away after their encounters. Some of the bouts of antennal boxing resulted in one of the participants adopting a submissive posture (see 2.3.6.). After some time however the repeated confrontations became more physical. There was momentary contact of the mandibles, the ants nudged heads or stood over one another's thoraces. Fighting sometimes followed; one ant held the other's mandibles (or their antennae or petiole) and lifted it off the ground. Some ants were dragged around. Tests involving adjacent and distant colonies gave similar results.

In contrast, all the interactions between nestmates were very short-lived (except for the first confrontation) (Table 10a), and they were of a different nature. When ants from distant nests within the same colony were tested, their interactions were sometimes initially slightly longer than those between

inhabitants of the same nest. After a few minutes however there were no more differences in the duration of the interactions. The lengths of the antennations cannot be compared statistically within and between tests. Times decrease with each encounter, and it is the entire sequence of antennation that must be considered. In addition, the number of encounters varies between pairs of ants in each test, because encounters in the arena occur randomly.

In summary, the main distinguishing feature between interactions involving nestmates and aliens was the end process; only in the latter did the repeated encounters lead to aggression.

Table 10a Length of the antennations between alien ants confined in a test arena. Two pairs of foragers were used in each recognition test; each pair belonged to the same nest. Different categories of nest relationships were tested: (a) distant nests within the same colony; (b) and (c) nests from adjacent colonies; (d) nests from distant colonies. Times are in seconds; "?" indicates an interaction that could not be timed.

(a)

	X1	X2	Y1	Y2
X1		1;0,5	2	6,5;?;?;2
X2			3,5;2;2;2	?;1;1,5
Y1				2,5;?;1,5;2,5;?;1,5
Y2				

(b)

	A1	A2	B1	B2
A1		3;1,5;0,5;1,5	5;2;1;2;1;?;2;2;1,5;2;1,5;1	7;4;?;3;3;2,5;1;1,5;1
A2			6;4;2;2;4;4;1;5;2;1	3;1;5;4;2;1,5;1;4;2;0,5;2
B1				2;?;2;1;2,5;0,5;2;?;2
B2				

(c)

	D1	D2	B3	B4
D1		1;2;1;0,5;2;?	4,5;2,5;4;?;3;2;?;1;?	?;5;2,5;2,5;?
D2			4;5;4;7;?	5,5;5;5;3;3;2
B3				2;?;?;1
B4				

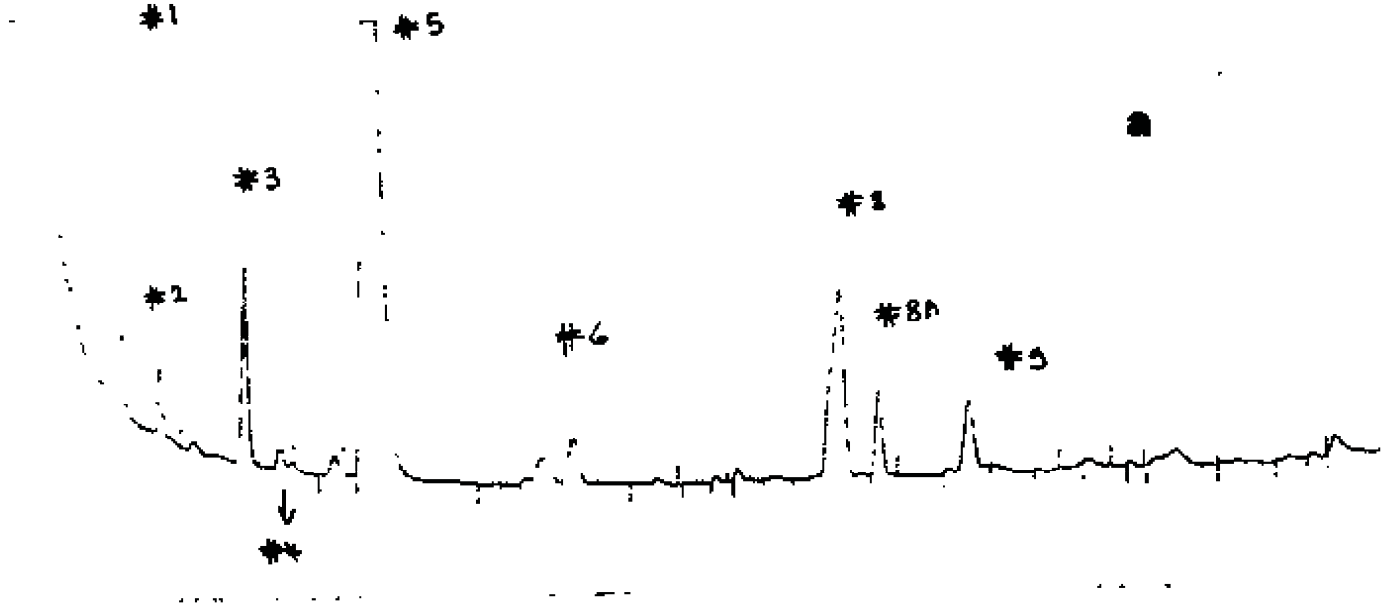
(d)

	A1	A2	C1	C2
A1		1,5	16;?;3	15;?;6;7;?;12
A2			10;2;?;10;5;3;4;3;2;3	10;6;4;13;2;?;4;5
C1				1;2;1,5
C2				

Addition to p.54 (Figure 6)

As stated in the text (p. 53), this analysis of the composition of mandibular gland secretions is preliminary. The extracts of over 10 individuals were analysed for each of the three categories of workers. These worker categories were arbitrarily constituted. A group such as the Innendienst workers included individuals with a substantial range of ages, and thus within-group variability could be expected. Notwithstanding, some consistent differences in the relative amounts of certain components were visually apparent between categories. None of the components have been chemically identified, and thus bioassays could not be attempted to determine which of the components are behaviourally important. The short reference to these incomplete results and the tentative suggestion of a change in the blend of components with age was merely intended to indicate that there may be pheromonal means through which within-nest recognition of individuals takes place.

Figure 6 Gas chromatograms of the mandibular gland secretions of three functional categories of workers of Ophthalmopone berthoudi (a) Innendienst workers, (b) foragers, (c) breeding workers.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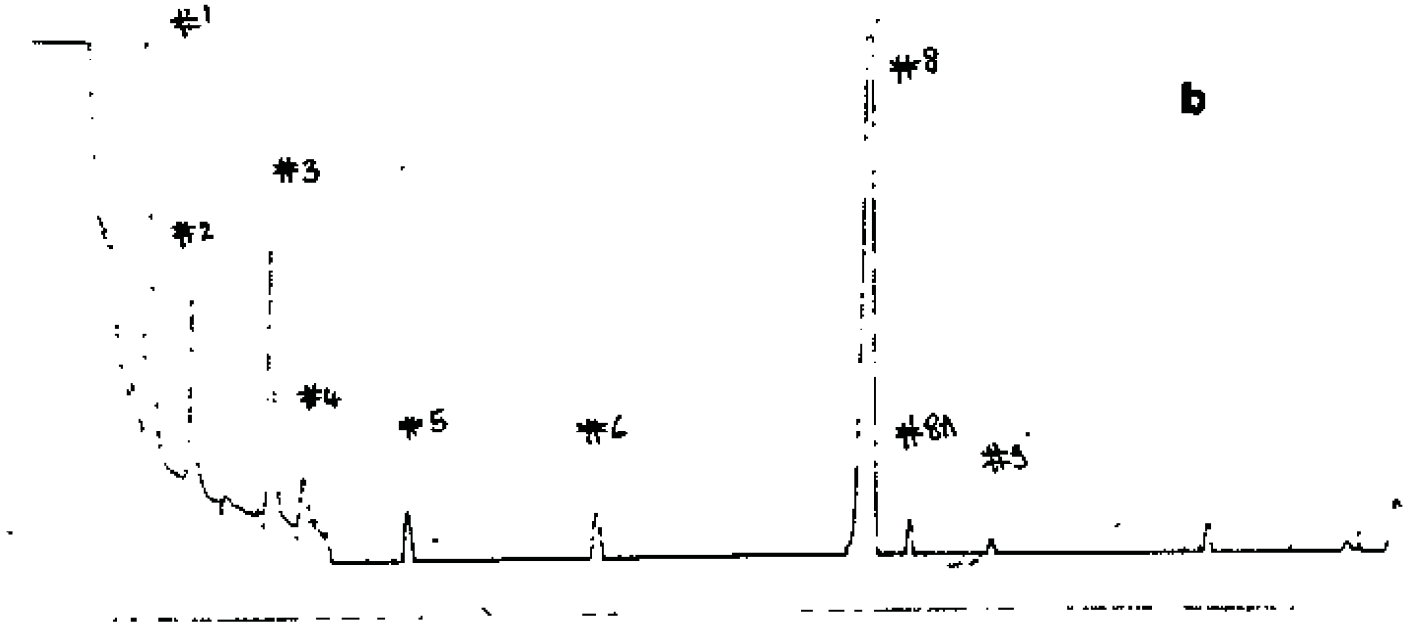
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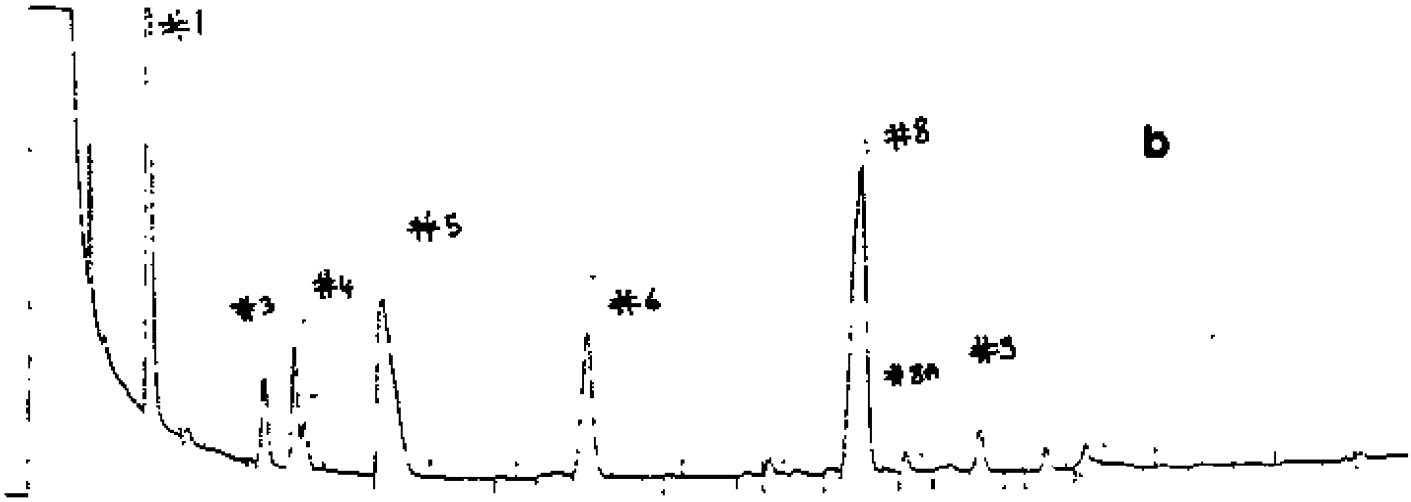
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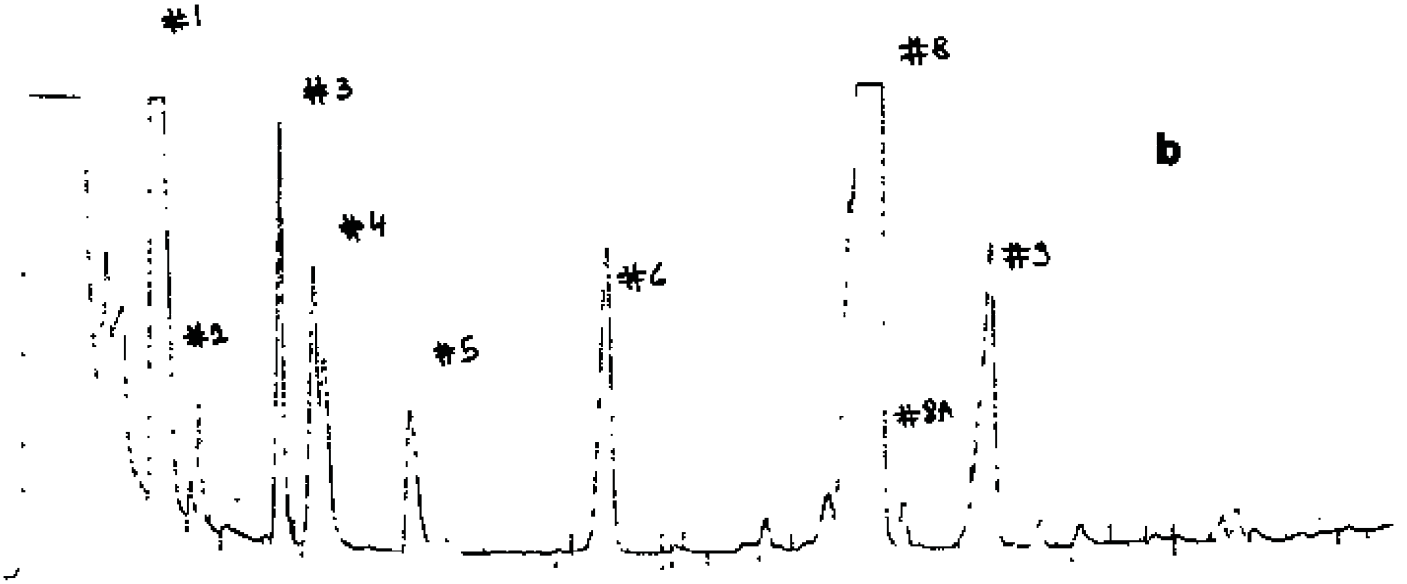
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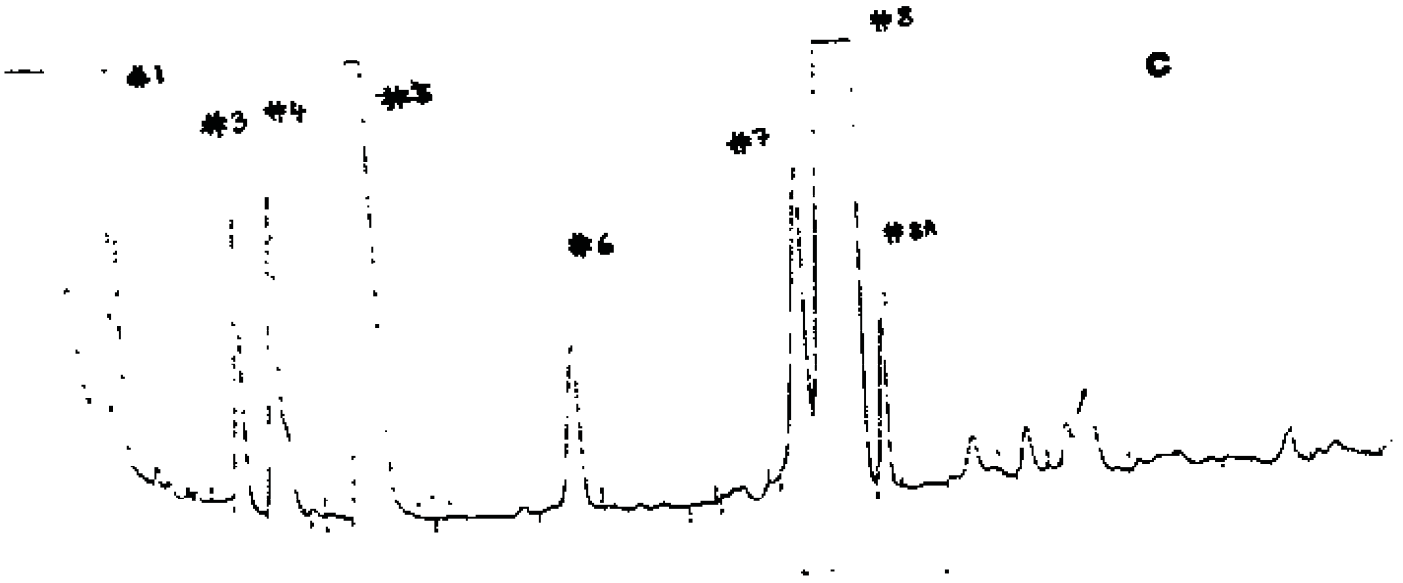
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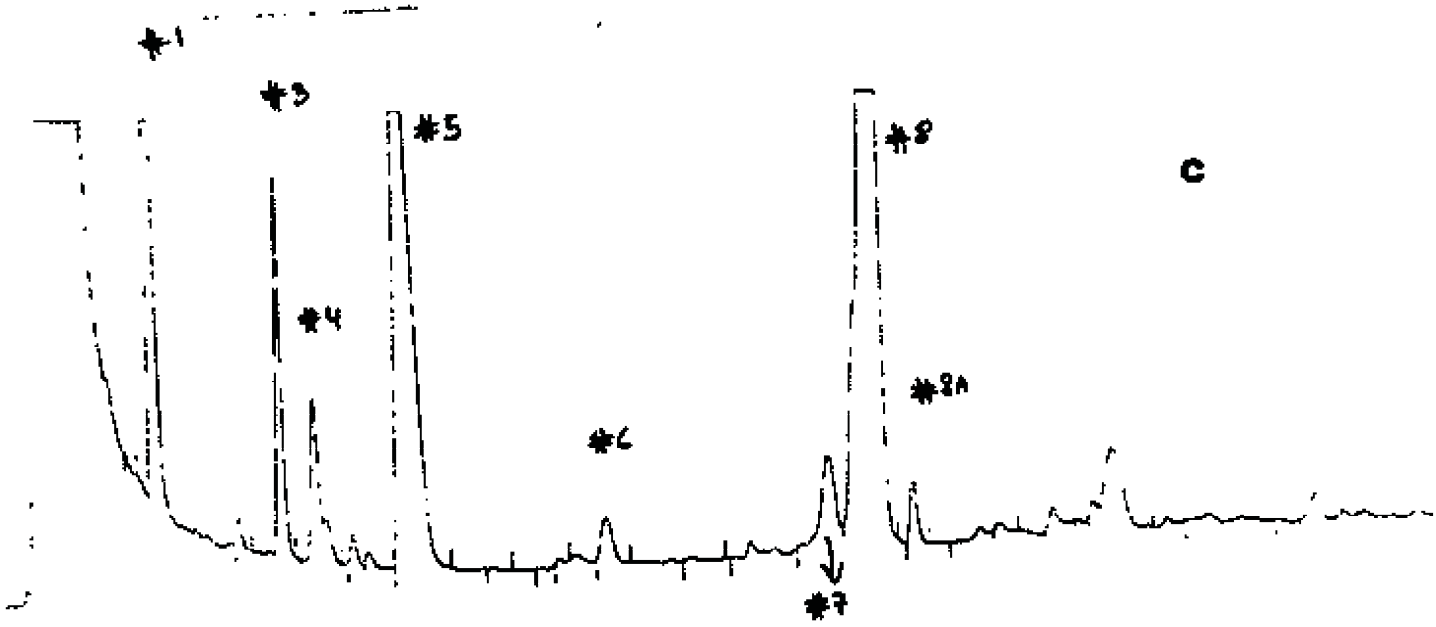
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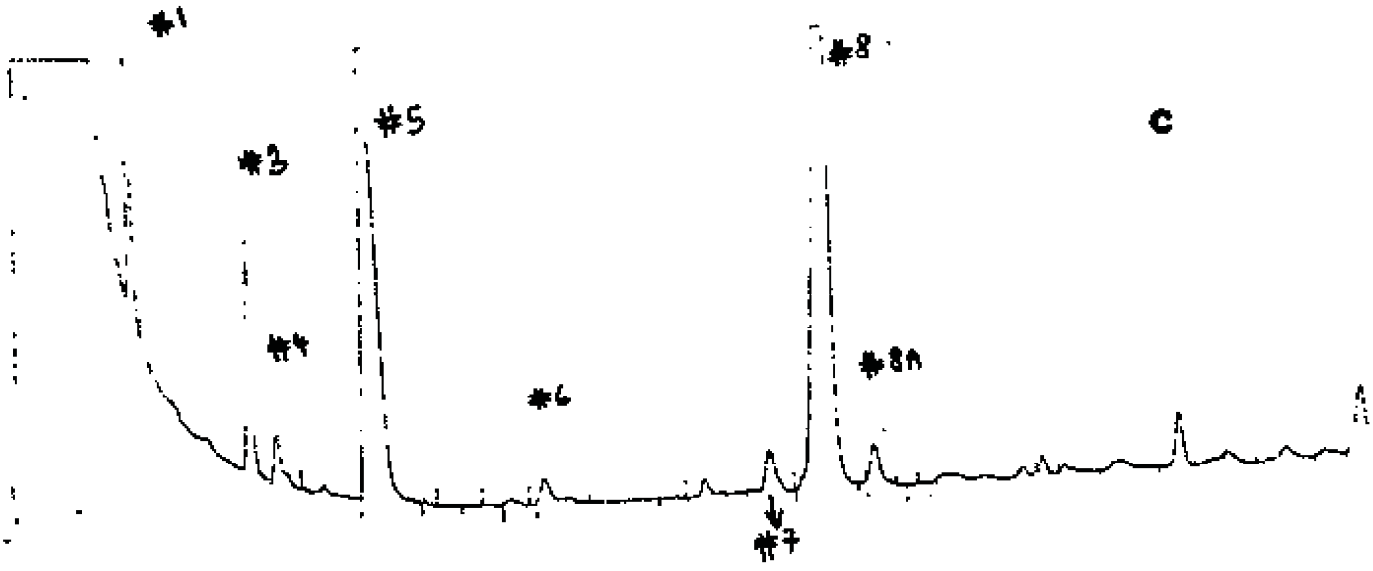
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Addition to p.77 (Standard deviations in Table 15)

Table 15 Measurements (with standard deviation) (in mm) of the head and gaster of breeding and sterile workers. Significance levels (*= p<0,05; **= p<0,01; ***= p<0,001) computed for the means of two samples by t-test.

	sterile workers	breeding workers	t-value & significance
Sample size	29	10	
Mean length of head capsule	2,59±0,07	2,58±0,04	0,58
Mean width of head capsule	1,76±0,06	1,78±0,04	0,88
Mean height of 1st gaster segment	2,22±0,13	2,35±0,07	3,03 **
Mean length of 1st gaster segment	1,56±0,11	1,73±0,08	4,38 ***

TRANSCRIPT A

Computer-generated print-out, listing the activities performed by the marked ants from colony (3a) during October 1981. Each page refers to a different observation session (eg. 04A; A= morning, P= afternoon); repetitions and redundancies have been eliminated. First entry refers to an ant's identity code, second entry to the activity observed, third entry to the nest in which active. Fourth and fifth entries are used when adults, brood or termites were transferred between nests; the former denotes the nest of destination and the latter the identity of marked recruits (when these were unmarked, it is indicated by XXX; when these were marked but the code could not be read, it is indicated by X). A list is given to convert the colour codes used in the print-out to the identity codes used in the text (eg. GYX = $31). The various activity codes are as follows: INS= found inside nest; ABO= unspecified above ground activity; EXC= excavating; CLE= nest sanitation; REC, EGG, LAR, COC, TER= adult, egg,larva,cocoon and termite transfer respectively; WAK= walking between nests; FOR= foraging; CAR= carried between nests. Nest entries refer to the following nests in Figure 5: ZE=(P); JU=(Q); AD=(R); DE=(S); OL=(XX); WWW refers to unknown above ground location.

YYY	$1
YYR	$2
YYG	$3
YYX	$4
YYB	$5
YGY	$6
YGR	$7
YGG	$8
YGX	$9
YGB	$10
YRY	$11
YRR	$12
YRG	$13
YRX	$14
YRB	$15
YXY	$16
YXR	$17
YXG	$18
YXX	$19
XYB	$20
YBY	$21
YBR	$22
YBG	$23
YBX	$24
YBB	$25
YBW	$26
YWB	$27
GYY	$28
GYR	$29
GYG	$30
GYX	$31
GGY	$32
GGR	$33
GGG	$34
GGX	$35
GRY	$36
GRR	$37
GRG	$38
GRX	$39
GXY	$40
GXR	$41
GXG	$42
G2	$43
Y4	$44
R4	$45
G4	$46
B4	$47
RYY	$48
RYR	$49
RYG	$50
RYX	$51
RYB	$52
RRY	$53
RRR	$54
RRG	$55
RRX	$56
RRB	$57
RGY	$58
RGR	$59
RGG	$60
RGX	$61
RGB	$62
RBY	$63
RBR	$64
RBG	$65
RBX	$66
RBB	$67
RXB	$68
R2	$69
RXG	$70
RXY	$71
RXR	$72
WWW	$73
WWR	$74
WWG	$75
WWB	$76
WWY	$77
WBX	$78
WBB	$79
WBW	$80
WBR	$81
WBG	$82
WRR	$83
WRX	$84
WRY	$85
WRG	$86
WRW	$87
WYY	$88
W2	$89
WGG	$90
W4	$91
WCG	$92
WGR	$93
WGW	$94
WGB	$95
BBB	$96
BBX	$97
BBR	$98
BBW	$99
BBG	$100
BGB	$101
BGX	$102
BGG	$103
BGY	$104
BGR	$105
BRR	$106
BRY	$107
BRG	$108
BRX	$109
BYY	$110
BYX	$111
B2	$112

BWB	$113
BWR	$114
BWG	$115
BWX	$116
BWW	$117
R=RW	$118
R=RG	$119
R=RY	$120
R=RB	$121
R=RX	$122
R=RR	$123
Y=YR	$124
Y=YW	$125
Y=YX	$126
Y=YG	$127
Y=YB	$128
Y=YY	$129
Y=YRY	$130
Y=YGR	$131
G=GX	$132
G=GR	$133
G=GY	$134
G=GG	$135
G=GW	$136
B=BY	$137
B=BX	$138
B=BR	$139
B=BG	$140
B=BW	$141
W=WB	$142
W=WR	$143
W=WX	$144
W=WG	$145
W=WY	$146
G=GB	$147
G=GYR	$148
R=RGY	$149
R=RWG	$150
Y1	$151
Y12	$152
Y1B2	$153
Y1R2	$154
Y14	$155
Y1R4	$156
Y1G4	$157
Y1W4	$158
W1	$159
W12	$160
W1R2	$161
W14	$162
G1	$163
G1R2	$164
G1Y2	$165
G1B2	$166
G14	$167
G1Y4	$168
G1R4	$169
B1	$170
B12	$171
B1Y2	$172
B14	$173
R1	$174
R12	$175
R1G2	$176
R1Y2	$177
R14	$178
R1G4	$179
R1B4	$180
R1Y4	$181
G4Y5	$182
G4R5	$183
R4Y5	$184
R4G5	$185
R4W5	$186
R4B5	$187
Y4G5	$188
Y4B5	$189
Y4R5	$190
B4W5	$191
B4Y5	$192
B4R5	$193
B4G5	$194
RXYR	$195
RXXG	$196
RXYB	$197
RXGR	$198
RXGY	$199
RXGB	$200
RXBR	$201
RXBG	$202
RXBY	$203
RXRB	$204
RXRY	$205
RXRG	$206
RYYR	$207
WXYR	$208
WXGR	$209
WXBR	$210
WXRG	$211
WXRY	$212
WXRB	$213
GXRY	$214
GXRG	$215
GXYR	$216
GXYG	$217
GXBG	$218
GXGB	$219
GXGR	$220
GXGY	$221
GRBY	$222
GRYB	$223
BXGR	$224

BXGY	$225
BXGB	$226
BXRG	$227
BXRY	$228
BXRB	$229
BXYG	$230
BXYR	$231
BXYB	$232
BXWB	$233
BXBW	$234
BXBY	$235

DATA FOR DAY 01A

B4	ABO	AD		
RBR	ABO	MZ		
YRB	ABO	ZE		
YYB	LAR	ZE	WW	
YYX	EXC	AD		

DATA FOR DAY 02A

W4	ABO	ZE		
W4	EXC	ZE		
BRY	ABO	ZE		
GGR	EXC	ZE		
GGY	FOR	ZE		
GYY	ABO	ZE		
RRX	ABO	ZE		
WBR	ABO	ZE		
YBB	REC	ZE	AD	XXX
YBX	REC	ZE	WW	YXG
YGB	WAX	ZE		

DATA FOR DAY 03A

```
[illegible] FOR AD
G2 FOR ZE
G4 ABO JU
K4 CLE ZE
[illegible] ABO AD
Y4 FOR ZE
GGA ADO JU
GGA ABO AC
GGR FOR ZE
GGY FOR AD
GRG ABO AD
GRX FOR ZE
GYX ABO ZE
GGR FOR ZE
GGX EXC JU
GGY FOR AD
GRR ABO ZE
GRX FOR ZE
GXG ABO ZE
GYY ABO ZE
RBB FOR ZE
RBR ABO ZE
RCG CLE AD
RRG FOR ZE
RRG ABO AD
RRR FOR AD
RRY ABO AD
RRY CLE ZE
RXG ABO AW
RXY CLE ZE
RYG FOR AD
RYX ABO ZE
RYX ADO AD
RYX TER AD ZE
RYX CLE ZE
RGB FOR ZE
RBG FOR ZE
RBW ABO ZE
RBX ABO ZE
RGX TER JU ZE
RRX ABO ZE
RRY ABO ZE
RRY FOR WW
RRG FOR ZE
RWR ABO ZE
RWR FOR ZE
RWR ABO JU
RYY ABO ZE
YBB CLE AD
YBR ABO ZE
YBX ABO ZE
YGB CLE ZE
YCG ADO ZE
YGX ABO ZE
YRR FOR ZE
YXX FOR AA
YYB ABO AD
YWG ABO ZE
YXR FOR AA
YXR FOR ZE
YYG ADO AA
YYR ABO ZE
YYR REC AD WW XXX
YYX ABO ZE
YYX TER ZE AD
YYY ADO ZE
R=RR ABO ZE
A=AY EXC JU
Y=YAY REC ZE AA XXX
```

DATA FOR DAY 04A

```
G4 ABO ZE
R2 REC WW JU X
R2 REC ZE JU ARR
R2 CLE JU
R4 FOR ZE
Y2 ABO ZE
Y2 FOR ZE
Y4 FOR ZE
BGR ABO ZE
BRG CLE JU
BRG ABO AD
BRG REC AD WW XXX
BRX ABO AD
BRX ABO JU
BRY ABO ZE
BWX FOR ZE
GGR ABO MI
GRG FOR ZE
GXG CLE ZE
GYY ABO ZE
RBX ABO ZE
RGB ABO MI
RGB ABO ZE
RGG ABO ZE
RCG REC ZE AD WRG
RRG ABO ZE
RRX FOR ZE
RRY CLE ZE
RRY EXC ZE
RXG ABO AD
RXG WAK AD ZE
RYG FOR WW
RYG FOR AD
WBN ABO ZE
WBX ABO ZE
WBX CLE ZE
WGW EXC ZE
WRG CAR ZE AD RGG
ARR CAR ZE JU R2
ARY FOR ZE
AWR ABO ZE
AWR REC WW ZE
YBG CLE AD
YBA ABO ZE
YGG ABO ZE
YGG ABO ZE
YGG CLE ZE
YGY FOR WW
YRB ABO ZE
YRX ABO ZE
YAY FOR ZE
YAY CLE ZE
YYX ABO ZE
YYY FOR ZE
G=GY ABC ZE
R=RG ABO ZE
R=RG ABO JU
R=RG FOR WW
R=RX FOR ZE
R=RX FOR JU
W=WY FOR ZE
Y=YG WAK ZE JU
Y=YG LAR ZE JU
Y=YA ABO ZE
Y=YRY LAR ZE WW
Y=YRY ABO JU
```

DATA FOR DAY 64P

```
G4 CLE WW
C4 CLE ZE
G4 EXC ZE
R2 CLE ZE
R2 EXC ZE
R2 FOR JU
R4 ABO ZE
Y2 FOR ZE
Y2 FOR ZE
BBB ABO ZE
BBA ABO ZE
BBX REC ZE JU RXG
BRX ABO ZE
BRR CLE ZE
GGG FOR JU
GGR FOR ZE
GXR ABO JU
GYC ABO ZE
GYY ABO JU
RGR FOR ZE
RGX FOR WW
RGY ABO ZE
RGG EXC ZE
RRY CLE WW
RRY EXC ZE
RXG ABO ZE
RXG CAR ZE JU BBX
RXC REC JU ZE YRY
RXG CLE ZE
RXG REC ZE JU RGB
XBR ABO ZE
XGW ABO ZE
XXG ABO ZE
XRR ABO JU
XRY FOR ZE
XXG ABO ZE
XWG ABO ZE
XWK ABO ZE
XWK CLE ZE
XXR ABO JU
XXR EXC JU
XXR ABO ZE
XYY FOR WW
YBX CLE ZE
YBY FOR ZE
YGG ABO ZE
YGX ABO ZE
YGX REC ZE JU XXX
YRY ABO JU
YXY EXC JU
YXC FOR ZE
```

```
YXY CLE ZE
YYC ABO ZE
YYR ABO ZE
YYR CLC ZE
YYX FOR ZE
YYY ABO ZE
R=XG CLE ZE
R=RX FOR WW
R=RY ABO ZE
Y=YB ABO ZE
Y=YRY ABO WW
Y=YRY CLE ZE
```

DATA FOR DAY 05A

B4 FOR AD
G1 REC WW ZE R2
G2 ABO ZE
G2 FOR ZE
G4 CLE AD
R2 CAR WW ZE G1
R4 CLE ZE
W1 ABO ZE
Y1 ABO WW
Y2 FOR WW
Y2 FOR JU
Y4 FOR ZE
BBW ABO AD
BBX CAR JU ZE WGR
BGG ABO ZE
BRG CLE AD
BRY ABO ZE
BWR CLE WW
BWW ABO ZE
BWW ABO AD
BYX ABO ZE
GGG FOR JU
GGR ABO ZE
GGX ABO ZE
GGY ABO AD
GXG FOR ZE
GXY CLE WW
GXY CLE AD
GYY ABO ZE
GYY LAR ZE JU
R14 ABO ZE
RBR ABO AD
RGG ABO ZE
RRB ABO JU
RRG CLE AD
RRG LAR ZE AD
RRR FOR AD
RRX FOR WW
RRY REC ZE AD WBW
RRY LAR ZE AD
RXB FOR WW
RXB FOR ZE
RXY ABO AD
RYG FOR WW
RYG FOR AD
RYY ABO AD
WBG ABO ZE
WBR FOR WW
WBR ABO ZE
WBW CAR ZE AD RRY
WBW CLE AD
WBX FOR ZE
WGR ABO ZE
WGR REC JU ZE BBX
WRG ABO AD
WRX ABO ZE
WRY FOR WW
WRY ABO ZE
WRY FOR ZE
WWG ABO ZE
WWR CLE AD
WWR ABO ZE
WWR TER JU ZE
WWW ABO ZE
WWY ABO ZE
YBG ABO AD
YBY FOR ZE
YGR ABO JU
YRB FOR WW
YRX FOR ZE
YRY ABO ZE
YWB ABO AD
YYR WAK ZE JU
YYX FOR WW
YYX ABO ZE
YYX FOR ZE
B4W5 ABO ZE
B4W5 REC ZE JU Y=YRY
G1R2 ABO ZE
G=GG ABO ZE
G=GG FOR ZE
R1G4 CLE ZE
R1Y2 ABO WW
R=RB ABO ZE
R=RB FOR WW
R=RB FOR ZE
R=RG ABO AD
R=RY ABO ZE
W1R2 ABO ZE
W1R2 ABO AD
Y1B2 ABO ZE
Y4B5 ABO JU
Y4B5 ABO ZE
Y4B5 WAK ZE JU
Y4B5 ABO AD
Y4G5 ABO ZE
Y=YX LAR ZE JU
Y=YX REC ZE JU XXX
Y=YY CLE ZE
R=RWG ABO WW
Y=YRY ABO JU
Y=YRY CAR ZE JU B4W5

DATA FOR DAY 05P

R2 ABO AD
R4 FOR WW
W1 ABO ZE
BBB FOR ZE
BBR ABO AD
BGX ABO ZE
BYX ABO ZE
BYY CAR ZE OL WBX
GGR ABO ZE
GGX EXC JU
GGY FOR WW
GRX FOR WW
GXG FOR ZE
GYY COC ZE JU
R14 EGG ZE JU
RBX FOR ZE
RGG EXC AD
RRX ABO ZE
RRY EXC ZE
RXB ABO ZE
WBX REC ZE OL BYY
WGX CLE JU
WRX ABO ZE
WRY FOR ZE
WYY FOR ZE
YGR FOR JU
YGY ABO ZE
YRX ABO WW
YRY ABO ZE
YWB ABO AD
YYX FOR ZE
B4W5 COC ZE JU
R=RR ABO JU
R=RX FOR WW
RXGR ABO ZE
W1R2 CLE ZE
W=WY FOR ZE
W=WY ABO JU
WXYR ABO ZE
Y1B2 TER ZE JU
Y4B5 ABO ZE
Y=YB COC ZE JU
Y=YB REC ZE JU XXX
Y=YW COC ZE JU
Y=YW WAK JU ZE
Y=YW EGG ZE JU
Y=YX CLE WW
Y=YY ABO ZE
Y=YY CLE WW
G=GYR ABO AD

DATA FOR DAY 06A

B2 ABO ZE
B4 FOR WW
R1 INS ZE
R2 FOR WW
W1 INS ZE
W4 INS ZE
BRG ABO WW
BRX ABO WW
BYY ABO OL
GGY ABO AD
GGY FOR WW
RBR ABO OL
RBY ABO ZE
RGB ABO OL
RGG ABO ZE
WRY ABO ZE
WWR ABO ZE
WYY FOR WW
Y14 INS ZE
YBB ABO JU
YGR FOR WW
YRB ABO ZE
YYB ABO ZE
B4Y5 ABO WW
B=BR INS ZE
G1B2 INS ZE
G=GB INS ZE
R=RY ABO OL
R=RY FOR OL
R=RY LAR ZE OL
RXYR ABO ZE
Y1B2 INS ZE
Y=YR ABO ZE
Y=YX ABO ZE
G=GYR INS ZE

DATA FOR DAY 07A

B2 INS DE
B2 ABO DE
G4 ABO AD
R4 FOR ZE
W2 REC WW WW XXX
Y1 LAR WW AD
BBB FOR ZE
BBW ABO DE
BBX ABO DE
BGB FOR JU
BYX REC ZE DE X
GGR ABO ZE
GGX ABO ZE
GRG FOR ZE
GRG ABO JU
GRX COC WW ZE
GRX FOR DE
GRX ABO JU
GXY ABO ZE
GXY ABO DE
GYG FOR DE
GYY COC AD ZE
RBY FOR JU
RGB ABO ZE
RGR ABO AD
RRG REC AD WW Y4B5
RRG ABO ZE
RRR FOR AD
RRX ABO ZE
RRY LAR JU ZE
RRY COC AD ZE
RXB CLE ZE
RXG CLE ZE
RXY FOR WW
RYX ABO ZE
RYY ABO ZE
WBG ABO ZE
WBR ABO ZE
WGR ABO AD
WGW ABO ZE
WGX LAR AD ZE
WRR ABO DE
WRX INS DE
WRX CLE ZE
WRX ABO DE
WRY FOR WW
WRY ABO ZE
WWG FOR ZE
WWW ABO ZE
WYY FOR ZE
XRG ABO ZE
Y14 CLE ZE
YBB ABO JU
YBY FOR ZE
YBY ABO DE
YGB ABO DE
YGG FOR ZE
YGR FOR ZE
YGX ABO ZE
YRX CLE ZE
YRX ABO DE
YRX TER ZE DE
YRY ABO ZE
YRY CLE ZE
YRY ABO DE
YXG FOR ZE
YXY FOR WW
YYB FOR ZE
YYR ABO ZE
B=BX ABO ZE
G1Y2 ABO ZE
G=GB ABO ZE
G=GR FOR DE
G=GX ABO ZE
R1Y2 ABO JU
R=RB ABO JU
R=RB ABO ZE
R=RR FOR WW
R=RW ABO WW
R=RX FOR AD
RXGR ABO ZE
RXYR FOR ZE
RXYR ABO DE
WXYR INS DE
Y1B2 ABO DE
Y4B5 ABO ZE
Y4B5 CLE JU
Y=YB CLE ZE
Y=YG LAR WW ZE
Y=YR CLE ZE
Y=YW ABO ZE
Y=YX ABO JU
G=GYR ABO ZE
R=RWG ABO ZE

DATA FOR DAY 07P

B2 ABO DE
Y2 FOR JU
BBX ABO DE
BBX REC JU DE XXX
BRG ABO AD
BRY FOR ZE
BWR ABO ZE
GGR ABO ZE
GRX REC ZE DE XXX
GRX COC ZE DE
GYG ABO ZE
RRG ABO DE
RRX CLE ZE
W12 ABO ZE
WBW CLE AD
WGG EXC DE
WRR ABO DE
WWW EXC DE
WWY ABO DE
WYY FOR ZE
XRG ABO DE
YBB ABO AD
YGB ABO DE
YGG FOR ZE
YRX REC ZE DE XXX
YRY ABO DE
YXG ABO JU
YYR ABO DE
YYR REC ZE DE YYG
YYY ABO DE
G=GW ABO AD
R=RG ABO ZE
R=RG CLE ZE
R=RR ABO ZE
RXYR ABO DE
Y=YG ABO DE
Y=YR ABO ZE

DATA FOR DAY 08A

```
B2 INS ZE
B2 ABO DE
B2 REC ZE DE RRX
B4 FOR WW
B4 ABO AD
R1 INS ZE
R4 INS ZE
R4 ABO WW
R4 FOR WW
W1 INS ZE
W2 INS ZE
W4 INS ZE
W4 ABO ZE
W4 CLE JU
W4 ABO AD
Y1 ABO WW
Y1 ABO ZE
Y2 FOR WW
Y2 ABO JU
Y2 FOR JU
Y4 INS ZE
BBB INS ZE
BBB ABO ZE
BBW LAR ZE WW
BGB ABO WW
BGG INS ZE
BGG REC ZE AD
BGG REC ZE AD XXX
BGG WAK ZE AD
BGG REC ZE AD X
BGG WAK AD ZE
BGX CLE ZE ZE WRW
BGX CLE ZE
BRY INS ZE
BRY ABO ZE
BWG FOR WW
BWG ABO JU
BWG FOR JU
BWR ABO ZE
BWW ABO ZE
BWW CLE ZE
BWW ABO JU
BWW CLE JU
BYX ABO ZE
GGR ABO ZE
GGR FOR ZE
GGX FOR ZE
GGX CAR ZE JU Y4B5
GGY FOR WW
GRG INS ZE
GRG FOR ZE
GRX ABO DE
GRX ABO JU
GXY ABO DE
GXY ABO ZE
GYG INS ZE
GYG ABO ZE
GYG LAR JU ZE
GYG ABO DE
GYY ABO JU
GYY CAR JU ZE WBG
GYY ABO ZE
RBY INS ZE
RGG ABO WW
RGG FOR AD
RRB INS ZE
RRB ABO DE
RRB ABO ZE
RRG INS ZE
RRG EXC ZE
RRG CLE ZE
RRG ABO DE
RRX ABO DE
RRX CAR ZE DE B2
RRY ABO ZE
RRY LAR WW ZE
RRY CLE JU
RRY TER JU ZE
RRY CLE ZE
RRY EXC ZE
RXB INS ZE
RXB ABO ZE
RXB CLE ZE
RXG LAR ZE AD
RXY FOR AD
RYX INS ZE
RXY ABO ZE
RYY ABO ZE
W12 INS ZE
WBG ABO JU
WBG FOR WW
WBG REC JU ZE GYY
```

```
WBR INS ZE
WBR ABO ZE
WBR ABO DE
WBW ABO WW
WBX ABO ZE
WGG ABO DE
WGG EXC DE
WGR ABO JU
WGR FOR WW
WGX ABO JU
WGX REC AD ZE B4G5
WRW ABO ZE
WRX ABO DE
WRX ABO ZE
WRX CLE ZE ZE W1R2
WRX CLE ZE ZE WRW
WRY INS ZE
WRY ABO WW
WRY CLE ZE ZE WRW
WRY FOR WW
WWG ABO ZE
WWG FOR ZE
WWW ABO DE
WWY ABO ZE
WYY INS ZE
WYY ABO JU
WYY ABO ZE
XRG ABO DE
XRG ABO ZE
YBB ABO AD
YBB FOR JU
YBB CLE JU
YGB ABO DE
YGX INS ZE
YGY INS ZE
YGY FOR ZE
YGY CLE WW
YRB ABO ZE
YRR INS ZE
YRX LAR ZE DE
YRY ABO DE
YRY LAR ZE DE
YWB ABO AD
YXG ABO JU
YXR FOR WW
YXR ABO ZE
YXY INS ZE
YXY FOR ZE
YYB FOR WW
YYB FOR DE
YYB CLE ZE
YYR ABO DE
YYR ABO ZE
YYR REC AD WW XXX
YYR REC XE  W=WB
YYY ABO ZE
B4G5 CAR AD ZE WGX
B4W5 ABO JU
B=BX INS ZE
B=BX ABO JU
B=BY ABO ZE
B=BY CLE ZE
G1B2 INS ZE
G1Y2 ABO ZE
G=GG INS ZE
G=GG FOR ZE
G=GR ABO DE
G=GR ABO ZE
G=GR TER ZE DE
G=GW ABO AD
G=GW ABO ZE
G=GX INS ZE
G=GX LAR WW ZE
R1G2 CAR AD JU W=WG
R1G2 ABO JU
R=RB INS ZE
R=RB ABO ZE
R=RG ABO ZE
R=RR INS ZE
R=RW INS ZE
R=RW EXC ZE
R=RW ABO JU
R=RX FOR WW
RXBG ABO ZE
RXGB ABO ZE
RXGR INS ZE
RXGY ABO ZE
RXGY CLE ZE
RXRG CLE ZE ZE WRW
RXRY ABO JU
W1R2 INS ZE
W1R2 CLE ZE
W1R2 EXC ZE
W=WB ABO JU
W=WB CAR ZE YYR
W=WG ABO JU
W=WG REC AD JU R1G2
W=WG CLE JU
W=WR INS ZE
```

```
X=JY INS ZE
W=WY ABO ZE
WXGY ABO ZE
YXRG ABO ZE
GXYR ABO DE
Y1G2 CLC ZE
Y1B2 CAR ZE JU Y4B5
Y1G2 ABO JU
Y1G4 INS ZE
Y4G5 ABO ZE
Y4B5 ABO JU
Y4B5 REC ZE JU Y1B2
Y485 LAR ZE JU
Y4B5 REC ZE JU GGX
Y=YB ABO ZE
Y=YG ABO DE
Y=YR INS ZE
Y=YR EXC ZE
Y*YR CLE JU
Y*YW ABO ZE
Y=YW LAR JU ZE
Y=YX ABO JU
Y*YX FOR JU
G=GYR INS ZE
G=GYR ABO ZE
G=GYR ABO JU
R=RWG ABO ZE
R*RWG CLE AD
Y*YRY CLE ZE
Y=YRY FOR WW
```