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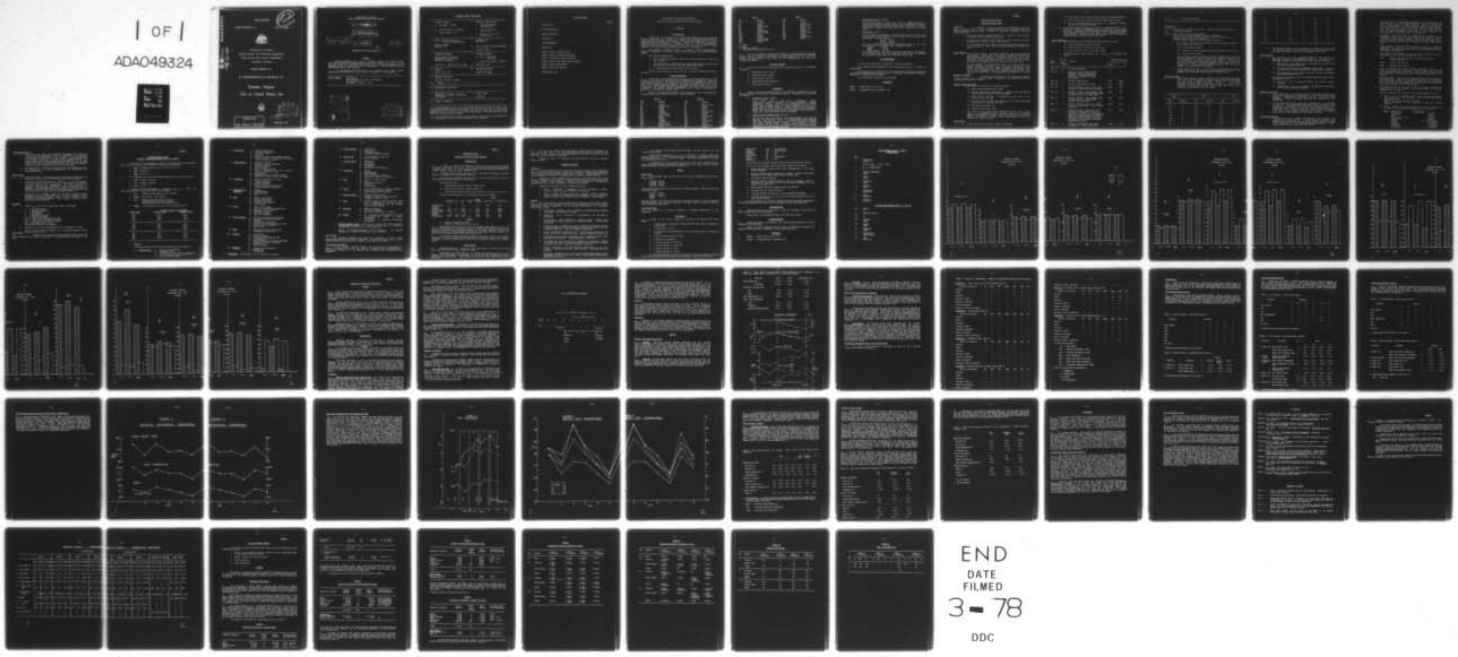

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AFFSE REPORT 5/77

AR No. 000862

Department of Defence
Defence Science and Technology Organisation
Armed Forces Food Science Establishment
Scottsdale, Tasmania

AFFSE REPORT 5/77

Operation Seaspray

Trial on Liferaft Rations (u)

September, 1977

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SUMMARY

During September, 1973 a trial of liferaft rations was held in Darwin. This report presents the combined medical-scientific findings of the trial. It was found that under the conditions of the trial, 500 ml of water per man per day was adequate, and 128 g of food (survival) was satisfactory. Food was preferred in the order barley sugar, fudge, glucose.

It was observed that the canopy of the liferaft could create adverse conditions and consideration could be given to redesign of this equipment.

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CONTENTS

OPERATION SEASPRAY

TRIAL ON LIFERAFT RATIONS

by
K.H. HEUSTON

INTRODUCTION

1. During 1971 the requirement for an improved liferaft ration was raised by the Royal Australian Navy (RAN). The project has since been progressed by the Armed Forces Food Science Establishment (AFFSE) under the direction of a Steering Committee within the Department of Defence. AFFSE has investigated a number of foods that could be suitable for a liferaft ration, but one, a 'Creamy Fudge' appeared to have more potential than the others due to the presence of small amounts of fat and protein as compared with a 'pure' carbohydrate.

2. The Steering Committee resolved to conduct a ration trial designated 'Operation Seaspray' to evaluate three types of rations, with restricted water intake.

3. The rations selected were:

a. The standard RAN liferaft ration, the solid portion of which is barley sugar.

b. The standard Royal Australian Air Force (RAAF) survival ration, the solid portion of which is a lightly compressed glucose.

c. A fudge containing carbohydrate, fat and protein.

Rations were provided at the rate of 128 g per day, together with 500 ml of water.

TRIAL COORDINATION

4. As the RAN was the sponsor Service it was given overall authority for the conduct of the trial and the RAN Trials and Assessing Unit (RANTAU) was instructed to coordinate the trial with Army, Navy and Air Force participating. Details of the trial requirements and coordination are given in an operation order with the short title 'Operation Seaspray' prepared by RANTAU and dated 19 July, 1973. This order covered the medico-scientific requirements of the trial, which are included as Annex B. The medical fitness requirements for test subjects (volunteers) as detailed in the order are given as Annex C.

5. Prior to the trial RAAF withdrew from participation and this necessitated a rearrangement of volunteers in the four rafts as follows:

RAFT A		RAFT D	
Men	Ration	Men	Ration
A1	Glucose	A2	Barley Sugar
A4	Barley Sugar	N2	Fudge
N5	Fudge	N4	Glucose
A7	Fudge	A5	Fudge
N8	Glucose	N7	Barley Sugar
A10	Glucose	A8	Glucose
N11	Barley Sugar	N10	Fudge
A13	Barley Sugar	A11	Barley Sugar
N14	Fudge	N13	Glucose
A16	Fudge	A14	Fudge
N17	Glucose	N16	Barley Sugar
A19	Glucose	A17	Glucose
N20	Barley Sugar	N19	Fudge
A22	Barley Sugar	A20	Barley Sugar
N23	Fudge	N22	Glucose

RAFT C		RAFT D	
Men	Ration	Men	Ration
N1	Glucose	S1	Glucose
A3	Fudge	S2	Barley Sugar
N3	Barley Sugar	S3	Fudge
A6	Fudge	S5	Barley Sugar
N9	Glucose	S6	Fudge
A9	Barley Sugar	S7	Glucose
N12	Barley Sugar	S8	Barley Sugar
A12	Fudge	S9*	Fudge
A15*	Glucose	S10	Glucose
N15	Fudge	S11	Barley Sugar
A18	Barley Sugar	S12	Fudge
N18	Barley Sugar		
A21	Fudge		

A = Army
N = Navy
S = Reserves (spares)
* Participants withdrew during trial.

6. It was not possible to obtain the services of a physiologist at the time of the trial. As a result it was decided to assess changes in morale by means of written reports prepared by the officer in charge of each raft. In all other aspects the performance of the trial was in accordance with the orders in 'Operation Seaspray'.

SECTIONAL REPORTS

7. Details of the various medico-scientific reports are given in the attached documents.

a. Biochemical tests (Annex C)

b. Medical/Fitness (Annex D)

c. Physiological (Annex D)

d. Meteorological data (Annex E)

e. Field tests (Annex F)

DISCUSSION

8. Each of the above mentioned reports cover detailed consideration of the results obtained in the area of investigation covered. Findings may be summarized as follows.

a. Biochemical Tests (Annex C)

Blood samples showed a slight rise in haemoglobin levels, haematocrit, sodium, creatinine and urea with decrease in plasma bicarbonate, chloride, potassium and a marked decrease in glucose. Urine samples showed about a 50 percent decrease, as did pH and creatinine. Potassium showed a slight decrease and there was a marked decrease in both chloride and sodium (each about 90 percent). There was a marked increase in urea for subjects on barley sugar or fudge, with a much smaller increase for glucose.

b. Medical/Fitness/Physiological (Annex D)

c. The clinical and physiological observations reported show that the subjects completed the trial in comparatively good physical condition. The analyses revealed no significant differences between the three rations tested. However, of potentially greater significance than the rations is the microclimate created by the raft canopy for this affects sweat loss which is a far more potent source of dehydration than urinary water loss.

d. Meteorological Data (Annex E)

The weather conditions ranged from true dry season conditions to humid pre wet season conditions with local thunderstorm activity. Observations inside the rafts indicated that conditions in Raft B were generally warmer, more humid and less ventilated than the other rafts.

e. Field Tests (Annex F)

No seasickness was recorded for the period of the trial and only five faeces samples were obtained. Urine volumes fell as the trial progressed: 1st day - 660 ml
2nd day - 464 ml
3rd day - 377 ml
4th day - 396 ml

The type of ration consumed had a significant effect on the urine volume but not on refractive index or specific gravity.

Glucose	- 439 ml
Fudge	- 410 ml
Barley Sugar	- 385 ml

The amounts of food and water returned are detailed in the Appendix and it appears that 500 ml of water and 128 gm 'food' was adequate for survival purposes under the conditions of the trial.

ACKNOWLEDGEMENTS

To the trial participants (volunteers) for their cooperation.

The assistance and cooperation of the three Service units in Darwin is acknowledged.

The assistance and cooperation of the Darwin Health Department Laboratory and the Water Resources Branch for provision of laboratory facilities and technical assistance is gratefully acknowledged.

To the sectional authors for their reports.

REFERENCES

RANTAU - OPORD dated 9 July, 1973.

RANTAU - Programme dated 4 September, 1973.

ANNEX A

SURVIVAL RATION TRIALS

MEDICO-SCIENTIFIC PLAN

Objective

1. In addition to the basic objectives of obtaining an improved type of liferaft ration, which currently consists of water and barley sugar, the medico-scientific tests will have a number of subsidiary objectives which are listed hereunder:

a. To compare glucose, currently used by the Australian Army and RAAF, with barley sugar currently used by RAN.

b. To measure the effects of small quantities of fat, protein and salt, as contained in fudge, on human water retention.

c. To obtain experience and develop techniques for more involved tests, to be proposed in detail later, on the desirability of drinking sea water.

Test Subject

2. a. The selected volunteer servicemen undergoing test will be known as test subjects. There will be fiftyone test subjects - seventeen from each Service, who have served continuously since Mar 73, in NSW. From these subjects, fortyfive, ie fifteen from each Service, will participate in the formal survival test. The other six will stand by to serve as replacements during the period of the formal test.

b. All test subjects will be between the ages of 18 and 40 years, of average physique, physically fit, able to swim 50 m and in good health, according to Service medical criteria vide Annex J. They will all be volunteers, but, before volunteering, will be made fully aware of the discomforts they will undergo during the test. They will also be made aware of the benefits that could result from the test.

Medical Screening

3. Prospective test subjects are to be medically screened in their holding unit. Medical fitness requirements and associated selection criteria are contained in Annex B .

Medico - Scientific Team

4. a. This team will comprise the following personnel -

(1) Defence Food Science Adviser (DFSA)

(2) Medical Physiologist from School of Public Health and Tropical Medicine (MP) and Physiologist from AFFSE(P)

(3) Three Medical Officers - preferably one from each of the Services (M01, M02, M03)

(4) Four Scientific Officers (S01, S02, S03, S04) and two Laboratory Assistants (LA1 and LA2) from AFFSE

(5) One Army Psychologist (AP)

(6) Observer from Defence (OD)

b. The team will also require some assistance from RAN shore support staff for non-technical aspects of their work, such as delivering samples and recording results. DFSA, as officer in scientific charge, will serve as liaison officer between members of the above team and the Naval OIC Trial.

Test Rations

5. a. Three rations will be tested. They will comprise:

(1) 500 ml water plus 128 gms of barley sugar to RAN specification;

(2) 500 ml water plus 128 gms of glucose to RAAF specification;

(3) 500 ml water plus 128 gms of fudge - a commercial product selected and evaluated by AFFSE.

b. The glucose and barley sugar will consist of carbohydrate only; the fudge will consist of carbohydrate plus small amounts of fat, protein and salt. AFFSE will provide seventy of each of the rations (water plus confection) required for the test. The confection will be vacuum packed in laminated pouches and the water will be contained in screw-top plastic jars with an airtight seal.

Feeding Regimen

6. a. The test period will be divided into three parts as follows:

(1) Initial on-shore period of two days.

(2) Period afloat in liferafts of four days.

(3) Final on-shore period of two days or less.

b. Activities during these periods are given in the following time table:

Test Sep 73	Day of Period Group A*	Activity	Observations Date Group A*	B*
Mon 10	-2	Fly Richmond-Darwin	-	-
Tues 11	-1	Settle in, set up tents prepare equipment, brief observers and subjects. Medical examination. Allocate fit subjects to rafts and rations.	-	-
Wed 12	1	Pre-raft observations.	Yes	None
Thur 13	2	Pre-raft observations continue.	Yes	None
Fri 14	3	Raft crews board in turn, after their 'Group B' observations made at beach.	None	Yes
Sat 15	4	Collect '1st day' urine, faeces, vomit and make 'Group B' observations, issue rations and water for first time.	None	Yes
Sun 16	5	Collect '2nd day' urine, faeces, vomit and make 'Group B' observations. Issue rations and water.	None	Yes
Mon 17	6	Collect '3rd day' urine, etc make 'Group B' observations. Issue rations and water.	None	Yes
Tues 18	7	Collect '4th day' urine, etc make 'Group B' observations at beach, followed by 'Group A' ones at Darwin. Each raft to be done in turn, hence bus shuttle to Darwin needed. Subjects released to eat and drink (well away from the waiting subjects) as their observations finish.	Yes	Yes
Wed 19	8	'Group B' observations and medical examination. Subjects then free.	None	Yes

Thur 20 - Fly Darwin-Richmond. - -

*Observations:

Group A: Exercise test, psychological tests. Samples of blood and urine for biochemical analysis.

Group B: Body weight and skinfold thickness.
Heart rate (lying and standing) and oral temperature.
24 hour urine: volume, specific gravity, 'acetest' reaction for ketones, glucose and protein screening.
24 hour vomit and faeces: weight and water content.

c. The rations available to test subjects during the above periods will be as follows (c.f. para 6a)

(1) normal without alcohol

(2) first day, no water or food; second day onwards, full survival

(3) normal without alcohol.

Survival rations will be issued to each test subject daily, except on the first day when no food or water will be taken, and there will be no interchange of rations between test subjects. However, any subject may save part of one day's survival ration for a following day, if he so desires. Unconsumed rations will be collected on the seventh day. No survivor will discard any part of his ration nor dispose of any packaging or containers.

d. During period (2) one or more 'stand by' subjects may be used to replace any subjects who have had to be withdrawn from the test. The exchange will be between test subjects on the same ration.

Statistical Plan

7. a. The 45 test subjects finally selected will be divided into three equal groups and each group allotted to one of three rafts designated 'A', 'B' and 'C'. Rations to these subjects will be provided according to the following plan where - A1 to A15 are 15 Army personnel, ranked in order of body weights from A_1 heaviest to A_{15} lightest: N_1 to N_{15} and F_1 to F_{15} are 15 Navy and 15 Air Force personnel, respectively, similarly ranked.

RAFT A		RAFT B		RAFT C	
Men	Rations	Men	Rations	Men	Rations
A_1	a	A_2	b	A_3	c
A_4	b	A_5	c	A_6	a
A_7	c	A_8	a	A_9	b
A_{10}	a	A_{11}	b	A_{12}	c
A_{13}	b	A_{14}	c	A_{15}	a
N_2	c	N_3	a	N_1	b
N_5	a	N_6	b	N_4	c

N_8	b	N_9	c	N_7	a
N_{11}	c	N_{12}	a	N_{10}	b
N_{14}	a	N_{15}	b	N_{13}	c
F_3	b	F_1	c	F_2	a
F_6	c	F_4	a	F_5	b
F_9	a	F_7	b	F_8	c
F_{12}	b	F_{10}	c	F_{11}	a
F_{15}	c	F_{13}	a	F_{14}	b

b. The remaining subjects will be allotted to a fourth raft, designated 'D', and each subject will be provided with a survival ration so that each type of survival ration will be consumed in this raft.

Physical Tests

8. a. The following tests will be performed daily, at the test site, on each test subject, tests commencing at 0800 hrs. The tests will be performed by members of the Medico-Scientific Team as indicated.

(1) Body weights in dry briefs after excretions (NO1) to provide an indication of body dehydration.

(2) Skinfold thicknesses using Harpenden calipers (NO2) - to provide an indication of tissue wastage due to insufficient calories.

(3) Oral temperatures, heart rates, lying and standing, and general clinical observations (MO3).

On the second and seventh days the following additional tests will be performed in Darwin -

(4) Efficiency, (MP) to determine fitness for further physical exertion.

(5) Psychological tests as considered appropriate by Army Psych. (AP), largely to determine morale.

Samples of Analyses

9. a. Blood samples will be collected from each test subject by MO1 on the second and seventh days and submitted to SO1 for the following analyses - haemoglobin, haematocrit, glucose, creatinine, urea, bicarbonate, sodium, potassium, chloride, total organic acids and osmolality.

b. The urine excreted by each test subject, each day will be collected by SO2 who will measure volume, specific gravity and ketones daily and prepare a representative sample from each test subject, on the second and seventh days, for SO1 for the following analyses - creatinine, urea, sodium, potassium, chloride, and total organic acid. SO2 will also measure and record the amount of faeces and vomit from each test subject and their water contents.

Conduct of Analyses

10 a. Paragraphs 9a and 9b require approximately 2,000 analyses, the results of most being required to a high degree of accuracy. It is intended that the analysis will be carried out by a group from AFFSE, using facilities at the Commonwealth Health Laboratories, Darwin, outside normal working hours, say 1530-2330 hrs.

b. With the use of auto-analytical techniques it is probable that the samples from Day 2 could be completed by Day 7 and the samples from Day 7 would require a further 4-5 days to complete. All analyses should be completed prior to the scientific officers leaving Darwin, which means that the team would have to remain 4-5 days after the test. One Scientific Officer (SO1) should be in Darwin 2-3 days prior to the commencement of the test to check equipment and facilities both in the field and in the laboratory.

c. Arrangements have been made for chemicals and equipment to be assembled at AFFSE. These could be transferred to Darwin, as soon as the majority of items are available, and held in Army/Navy stores. Provision of power, benches, refrigerator for samples only, and an adequate wash up/sterilising area is required for the field testing area.

d. Blood samples, collected on Day 2 and Day 7, will be a 'medical' responsibility as well as the provision of sampling equipment and containers. Suggested preservatives are listed below and a minimum 10 ml sample is required.

e. Daily tests to be performed in addition to the laboratory analyses discussed above are listed hereunder (SO2, SO3).

Urine - Volume, specific gravity, RI and screening ketones, albumin and sugar

Faeces - Quantity and moisture

Vomit - Quantity and moisture

f. Urine - Daily samples will be in plastic containers which must be clean and clearly and adequately labelled. Quantity and moisture will be determined daily in the field. Daily screening tests will be made using test strips/tablets in accordance with directions on the bottles.

g. Faeces and Vomit - Labelled containers and bags will be provided to each participant. They will be collected daily when fresh containers will be issued. Quantity and moisture contents will be determined daily in the field. The remainder of the sample will not be required for further analysis and will be discarded.

h. Particular attention will be paid to the collection, labelling and identification of all samples, particularly those for detailed analysis (Day 2 and Day 7).

i. Analytical samples (Day 2 and Day 7) will be preserved as follows -

(1) Urine - 24 hour composite samples should be kept refrigerated and preserved in two portions - 400 ml with 10 ml conc hydrochloric acid
100 ml with 5 ml 10 per cent W/V Thymol
Sample containers will be scrupulously clean and clearly labelled.

(2) Blood - Samples will be taken and held at 2-4 °C. A minimum 10 ml sample is required with preservatives as indicated for -

Tests -	Preservatives -
Haematocrit	Heparin
Haemeglobin	Heparin
Creatinine	Heparin
Urea	Heparin
Total Organic Acids	Heparin
Osmolality	Heparin
Glucose	Fluoride/Oxalate
Sodium	Ca Heparin
Potassium	Ca Heparin
Chloride	Ca Heparin
Bicarbonate	Ca Heparin

Meteorological Data

11 a. At the test site each day of the test, measurements of temperature (including globe thermometer), humidity, rainfall, cloud cover and wind velocity and direction will be recorded. These measurements will be taken at 0600 hrs, and every three hours thereafter. The micro-climate inside each liferaft will be assessed at the same times, by measuring globe thermometer temperatures, wet and dry bulb temperatures and wind speed and direction. Any other environmental factors, that could affect the test, will also be noted.

b. Arrangements will be made for an officer from the Commonwealth Bureau of Meteorology to accept responsibility for collecting all meteorological data.

Daily Routine

12. a. During the initial on-shore period of two days, test subjects will be quartered on-shore and will be available for tests as required.

b. During the four-day period afloat, rafts 'A', 'B', 'C' and initially 'D' will be towed to the test site to arrive at 0800 hrs, 0900 hrs, 1000 hrs and 1100 hrs, respectively. The test subjects will disembark, again use their containers for urine, faeces and vomit, if necessary, and then hand these to SO2. Each test subject will be tested as outlined in para 8 above, given three empty containers and then returned to his raft which will be towed off-shore.

c. During the final on-shore period of two days or less, the above procedure will be followed except that, after all Group 'B' tests have been performed and samples taken, the test subjects will be returned to their shore quarters. Here, Group 'A' tests as for the 7th day will be carried out.

Equipment

13. a. AFFSE will provide the following main items of equipment:

2 x Platform Scales
2 x Harpenden Calipers
2 x Stop Watches
2 x Hydrometers
2 x Measuring Cylinders
2 x Chemical Balances
102 x small rigid containers for urine
102 x large rigid containers for urine
102 x containers with lids for faeces
500 x minigrip bags for vomit
Replacement Chemicals and Equipment

b. Army Psych will provide questionnaires for psychological testing.

c. Navy will provide medical equipment for collecting samples of blood and for medical tests.

Final Report

14. AFFSE will be responsible for producing a report, under the joint authorship of all these contributing, on the medico-scientific aspects of the test.

ANNEX B

SURVIVAL RATION TRIALS
MEDICAL FITNESS REQUIREMENTS FOR TEST SUBJECTS

1. Volunteers are to be medically screened in their holding unit. Candidates must conform at least to the following Service medical categories.

a. ARMY - Pulheems profile P2 U2 L2 H2 E8/3 E8/3 M2 S2

b. NAVY - Category A

c. RAAF - A4 G2 O1 Z1

2. All volunteers are to be fully medical examined on the following forms:

a. ARMY - AF MED 1 (PM 149)

b. NAVY - AF MED 1 (PM 149)

c. RAAF - PM 128

3. In addition to the requirements of categories shown in a. above, the following additional criteria are to be fully observed.

a. Age — Between 18 years and 40 years inclusive.

b. Height — Min 166 cms Max 188 cms

c. B.P. — Systolic Max 140 mm Hg Min 90 mm Hg
Diastolic Max 90 mm Hg Min 60 mm Hg
Pulse pressure is not to exceed 50 mm Hg

d. Weight — Is to be within the limits of the following table.

Height (cms)	Weight (stripped) in kilograms Minimum (-20%)	Maximum (+20%)
166	50.0	76.0
168	51.0	77.0
170	52.0	79.0
172	53.0	80.0
174	54.0	82.0
176	55.0	84.0
178	57.0	86.0
180	58.0	88.0
182	59.0	90.0
184	60.5	91.5
186	61.5	93.5
188	63.0	95.0

e. History

A previous history of the following complaints will disqualify.

(1) Cardiovascular.
a. Persistent Hypertension.
b. Rheumatic fever.
c. Pericarditis, myocarditis or entocarditis.
d. Coronary disease or cardiac failure.
e. Major vascular disease.

(2) Respiratory.	a.	Genuine haemoptysis.
	b.	Pulmonary tuberculosis
	c.	Bronchial asthma
	d.	Hay fever
	e.	Chronic or recurrent pulmonary disease
	f.	Pleural effusion of undetermined aetiology within preceding 2 years.
(3) Genitourinary.	a.	Recurrent cystitis
	b.	Recurrent urinary infections
	c.	Urethral stricture
	d.	Renal calculus
	e.	Active Venereal disease
	f.	Chronic nephritis or acute nephritis within preceding 10 years.
	g.	Nephrectomy
	h.	Hydronephrosis or polycystic kidney
	i.	Neoplasm of kidney, ureter or bladder.
(4) Alimentary.	a.	Acute or chronic peptic ulcer.
	b.	Chronic dyspepsia
	c.	Ulcerative colitis
	d.	Chronic diarrhoea
	e.	Cholecystitis or cholelithiasis
	f.	Serious abdominal operation.
(4) Endocrine and Metabolic	a.	Diabetes
	b.	Hyperthyroidism
	c.	Hypothyroidism
	d.	Gout
(6) Skin	a.	Chronic skin disease
	b.	Chronic ulceration
	c.	Allergic skin rashes
	d.	Recurrent furunculosis
	e.	Hyperhidrosis.
(7) E.N.T.	a.	Acute otitis media.
	b.	Chronic otitis media or mastoiditis
	c.	Recurrent otitis externa
	d.	Recurrent sinusitis
	e.	Meniere's disease
	f.	Any aural operation.
(8) Nervous System	a.	Any previous psychiatric disorder.
	b.	Epilepsy or chronic blackouts.
	c.	Migraine/
	d.	Servere motion sickness.
	e.	Head injury within preceding 3 years.
	f.	Organic nervous disorder.
	g.	Heat stroke.
(9) Eyes.	a.	Recurrent infective conditions.
	b.	Degenerative conditions.
(10) Skeletal	a.	Arthridites.
	b.	Chronic backache.
	c.	Prolapsed intervertebral disc.
	d.	Poliomyelitis.
	e.	Spinal operations or spinal fractures.
	f.	Progressive muscular disorder.
	g.	Osteomyelitis.
	h.	Varicose ulcers.
(11) Haemoptic	a.	Chronic blood dysorasias.
	b.	Haemophilia.
	c.	Splenectomy.

f. Examination. Any evidence of the following will exclude.

(1) Cardiovascular	a.	Hypertension.
	b.	Aneurysm.
	c.	Arteriosclerosis.
	d.	Peripheral vascular disease.
(2) Respiratory.	a.	Active pulmonary condition.
	b.	Chest deformity.
(3) Genitourinary.	a.	Albuminuria
	b.	Glycosuria
	c.	Varicocoele.
	d.	Hydrocoele.
	e.	Epispadias or hypospadias.
(4) Alimentary.	a.	Hernia.
	b.	Abdominal mass.
	c.	Haemorrhoids.
	d.	Anal stricture or fistula.
	e.	Persistent abdominal tenderness.
(5) Skin	a.	Chronic or acute eczema
	b.	Acne.
	c.	Seborrheic dermatitis.
	d.	Psoriasis.
	e.	Furunculosis.
(6) E.N.T.	a.	Chronic perforation of tympanic membrane.
	b.	Active otitis externa or media.
	c.	Nasal obstruction or rhinitis.
(7) Nervous System	a.	Abnormal cranial nerves.
	b.	Evidence of organic nervous disorder.
	c.	Evidence of mental illness.
(8) Eyes	a.	Unaided vision to be at least 6/60 each eye and correctable to 6/12, 6/12 or 6/9, 6/18. Glasses may be worn but corneal lenses are not allowed.
(9) Skeletal.	a.	Unhealed fractures.
	b.	Nerve root pressure.
	c.	Any joint inflammation or swelling.
(10) Dental	a.	All volunteers must be dentally fit with no carious teeth evident on dental examination.
	b.	No evidence of gingival inflammatory conditions.

g. Specific Gravity Urine. Urine is to be tested for specific gravity and repeated if necessary to ensure that volunteer is capable of concentrating urine to a S.G. of at least 1015.

h. E.C.G. An electrocardiograph is to be carried out. Any abnormal tracings will necessitate rejection of the candidate.

Vaccination

4. All personnel attending the trial are requested to hold a valid International Health Certificate of Vaccination. These certificates must accompany Medical documents when forwarded to RANTAU in accordance with Annex F.

Psychological Screening

5. If the examining medical officer has any doubts as to the candidate's ability to complete the trial for reasons of psychological maladjustment, a psychologist's report is to be obtained and forwarded with the medical history documents.

ANNEX C

BIOCHEMICAL TESTS

ANALYSIS OF BLOOD AND URINE SAMPLES

INTRODUCTION

1. A trial to evaluate the effects of survival rations and restricted water was held in the Darwin (N.T.) area. Details of the trial requirements and programme of events are given in the operation orders from RAN Trials and Assessing Unit (RANTAU) dated 19 July 1973 and 4 September 1973.

2. Volunteers from the Army and Navy spent four days in inflatable liferafts moored in a remote area of the Darwin Harbour.

3. Rations were provided at the rate of 128 g of ration and 500 ml of water on the second, third and fourth days of the trial.

Rations used were:

a. Standard RAN survival ration - barley sugar.

b. RAAF survival ration - glucose tablets.

c. Candy creamy fudge containing small amounts of protein, fat and salt.

Details of the composition of each ration are given in Table I.

	MOISTURE %	FAT %	ASH %	PROTEIN %	CARBO-HYDRATE %	ENERGY K.CAL/100g	K.JOULES/100g
Barley Sugar	2.0	-	0.11	-	97.9	387	1630
Glucose Tablets	1.8	1.1	0.12	-	97.0	392	1650
Creamy Fudge	8.5	4.2	0.72	3.2	83.4	379	1600
Barley Sugar	2.56g	-	0.14g	-	125g	496	2080
Glucose Tablets	2.3g	1.4g	0.15g	-	124g	502	2120
Creamy Fudge	10.9g	5.4g	0.9g	4.1	106g	485	2040

TABLE I

1. Proximate Chemical Analyses
2. Amounts of components in daily ration.

4. Biochemical tests on both blood and urine samples were carried out both 'on site' and in the Health Laboratories, Darwin. AFFSE staff working outside normal hospital laboratory hours, completed the detailed analyses required, during the period of the trial. This was made possible by the cooperation and assistance of the staff at the Darwin Health Department Laboratories.

5. This sectional report covers the aspects of the trial related to the daily analyses 'on site' and the detailed analyses of blood and 24 hour urine samples collected on the day preceding the 'afloat' stage and the day following the 'afloat' stage.

FIELD TESTING

6. Temporary laboratory facilities were established at the trial site and daily tests were made on urine, faeces and vomit.

7. Measurements were made daily of the volume and specific gravity of urine samples. All urine samples were screened for pH, blood, bile, ketoses, glucose and protein using 'Bililabstix'. (Ames Company, Division of Miles Laboratories Ltd., Melbourne).

8. Provision was made for the measurement of total weight and moisture for both faeces and vomit. Only five faeces were collected and no seasickness was recorded. (Three volunteers were removed during the first day of the trial as they felt sick and did not wish to continue).

9. A detailed report of the results of field testing is given in a separate report (Annex F).

LABORATORY TESTING

Sampling

10. Fasting blood samples were taken by the medical team on the days preceeding and following the 'afloat' stage of the trail. Analysis of samples was commenced as soon as practical after sampling (usually within 2 hours). Where necessary, samples were preserved with heparin or fluoride/oxalate according to normal practice.

11. Twenty-four urine specimens were collected for the same times as the blood samples. Samples were collected in clean plastic bottles and collection supervised by Trials Staff. Where necessary, samples were preserved by refrigeration, hydrochloric acid or thymol depending on the analyses required.

12. Samples were analysed for the following parameters:

a. Blood - haemoglobin, haematocrit (P.C.V.), bicarbonate, sodium, potassium, chloride, urea, creatinine and glucose.

b. Urine - volume, specific gravity, pH, chloride, sodium, potassium, urea and creatinine. Samples were also screened for blood, ketoses, glucose, protein, and bilirubin using 'Bililabstix' (Ames Company).

Methods

13. The methods used for analyses were those in daily use at the Darwin Health Laboratories, and are outlined, details of the methods may be found in 'Micro' Analysis in Medical Biochemistry' by I.D.P. Wootton, published by J. & A. Churchill Ltd., London, (1964).

a. Haemoglobin - measured using an automatic haemoglobinometer (Beckman Instruments) and recorded as g/100ml.

b. Haematocrit (P.V.C.) measured by centrifugation and recorded as percentage.

c. Electrolytes - were measured on separated plasma. Samples were centrifuged and separated as soon as possible (within 2 hours) after collection.

d. Plasma chloride - determined by micro titration with mercuric nitrate to diphenylcarbazone using the method of Schales and Schales detailed in Wootton (see text). Results reported as mEq/litre.

e. Plasma bicarbonate determined using the volumetric method of Van Slyke, detailed in Wootton (see text). Results reported as mEq/litre.

f. Plasma sodium and potassium determined using a Beckman automatic flame photometer (see Wootton). Results reported as mEq/litre.

g. Urea determined using auto-analyser, (Technicon Instruments, Sydney) established for use with di-acetyl-phosphoric acid and method detailed in Wootton (see text). Results reported in mg/100 ml.

h. Glucose determined using auto-analyser established for use with cyanide - ferricyanide method (see Wootton). Results reported in mg/100 m.

i. Creatinine determined using colorimetrically/spectrophotometer (after development of colour with picric acid - Folin method (see Wootten). Reported as mg/100 ml.

Urine samples were analysed using the methods outlined above, with the following alterations.

Chloride was determined on a 1 in 20 dilution of sample, sodium and potassium determined on various dilutions within the range of flame photometer, urea was determined on a 1 in 20 dilution of sample. Creatinine determined as for blood but reported as mg/24 hours.

In addition pH, volume and specific gravity of the urine were measured by usual laboratory methods. Samples were screened for blood, bile, ketoses, glucose and protein using 'Bililabstix' (Ames Chemical Co.).

RESULT

Field Tests

14. Urine volumes fell as the trial (afloat stage) proceeded and the average volumes were:

1st Day - 600 ml
2nd Day - 464 ml
3rd Day - 377 ml
4th Day - 396 ml

Urine volumes varied with the type of ration consumed (average volumes for the last three days afloat).

Glucose - 439 ml
Fudge - 410 ml
Barley - 385 ml
Sugar

From the amounts of rations returned (see field report Annex F), it may be deduced that barley sugar was the most generally accepted ration followed by fudge and glucose tablets in that order.

Laboratory Tests

15. A summary of the results obtained is presented graphically in the Appendices

DISCUSSION

16. A study of the results shows the following with respect to the blood samples.

a. A slight rise in haemoglobin levels with the least rise in subjects on barley sugar.

b. A slight rise in P.V.C.

c. A decrease in plasma bicarbonate with the greatest drop in subjects on glucose.

d. A very slight increase in sodium

e. A decrease in potassium.

f. A slight decrease in chloride.

g. A marked increase in creatinine.

h. A marked increase in urea.

i. A marked decrease in glucose.

It was considered that the results obtained both before and after indicated only slight variations from the normal values (Wootton - see text) which are:

Haemoglobin	13.5	-	18.0 g/100 ml
Sodium	136	-	149 mEq/litre
Potassium	3.8	-	5.4 "
Chloride	96	-	107 "
Bicarbonate	24	-	33 "
Urea	14	-	50 mg/100 ml
Glucose	63	-	100 "
Creatinine	0.1	-	1.4 "

In all cases the behaviour pattern on the different rations was similar.

The 24 hour urine samples (before and after) showed the following.

a. Volume decreased by about 50 per cent irrespective of the solid ration consumed.

b. Specific gravity showed a marked and variable increase with ration influence in that order fudge, glucose, barley sugar.

c. pH showed a marked decrease.

d. Chloride showed a marked decrease of about 90 percent. This is indicative of salt retention in the body (renal conservation) in the absence of dietary salt.

e. Sodium showed a marked decrease similar to chloride.

f. Potassium showed a slight decrease.

g. A marked decrease (50 percent) in the creatinine discharged.

h. A marked increase in the urea level for fudge and barley sugar with much less for glucose.

It was considered that the urine analyses followed the pattern expected by the medical officers on the trial and no abnormalities have been determined.

RECOMMENDATIONS

17. Under the conditions of this trial it may be concluded that 500 ml of water per man per day is satisfactory.

Barley sugar is the preferred ration then fudge and glucose.

ACKNOWLEDGEMENTS

18. Particular thanks to the staff of the Darwin Health Laboratory for their assistance and cooperation.

Thanks to Water Resources Branch, Dept. of Northern Territory for assistance and provision of equipment for the field laboratory.

REFERENCES

1. RANTAU - OPORD dated 19 June, 1973

2. RANTAU - Programme dated 4 September 1973.

BLOOD SAMPLES (DAY 2 - DAY 7)
RATION TYPES

No.

1. Haemoglobin
   g/100 ml

   Ration types - Day 2 - Day 7

2. P.C.V. (Haematocrit)
   %

3. Plasma Bicarbonate
   (mEq)

4. Sodium
   (mEq)

5. Potassium
   (mEq)

6. Chloride
   (mEq)

7. Creatinine
   mg/100 ml

8. Urea
   mg/100 ml

9. Glucose
   mg/100 ml

24 HOUR URINE SAMPLES (DAY 2 - DAY 7)

10. Volume
    ml

11. Specific Gravity

12. pH

13. Chloride
    (mEq)

14. Sodium
    (mEq)

15. Potassium
    (mEq)

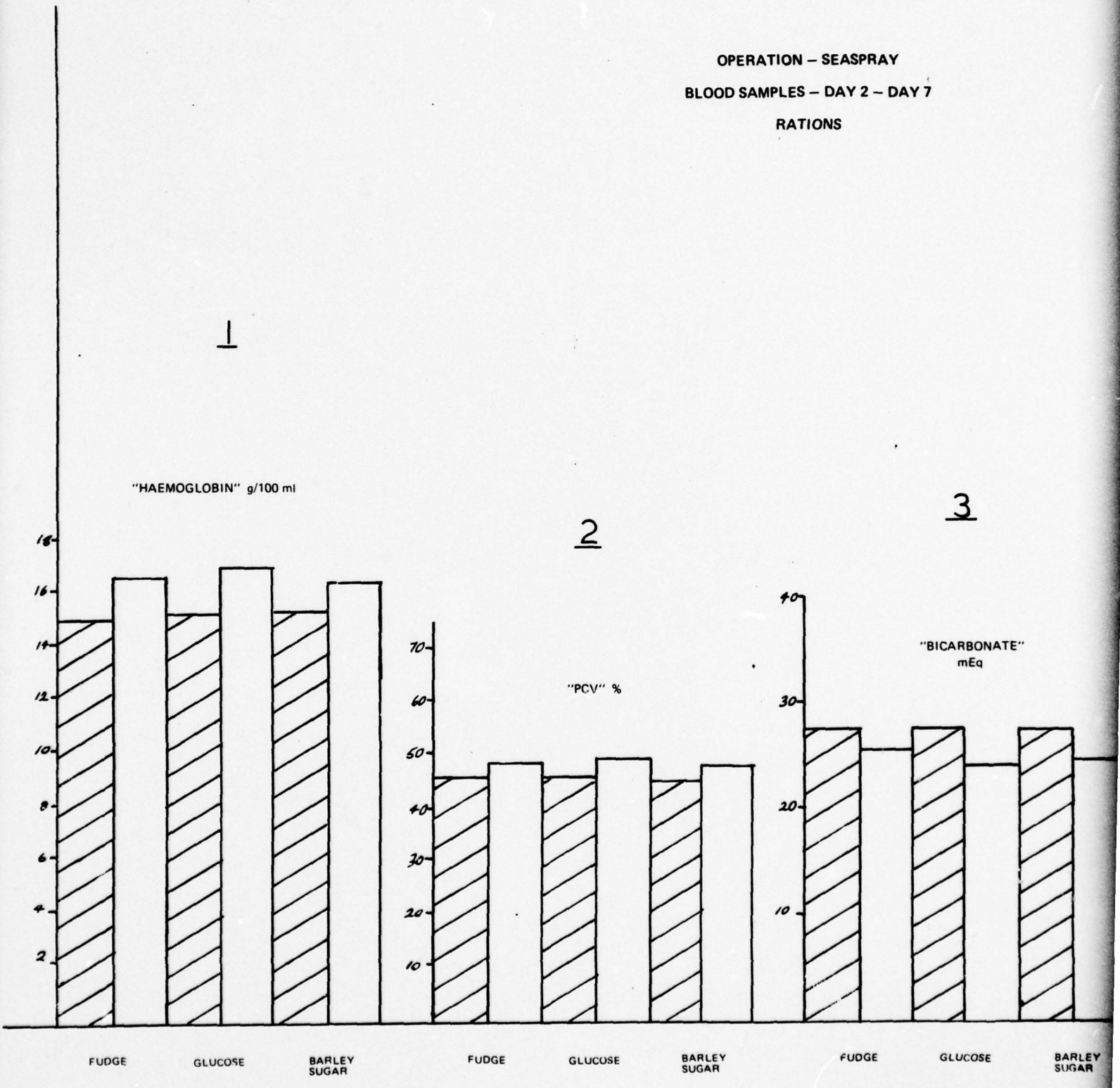
16. Creatinine
    (mg/24 hours)

17. Urea
    mg/100 ml

OPERATION – SEASPRAY

BLOOD SAMPLES – DAY 2 – DAY 7

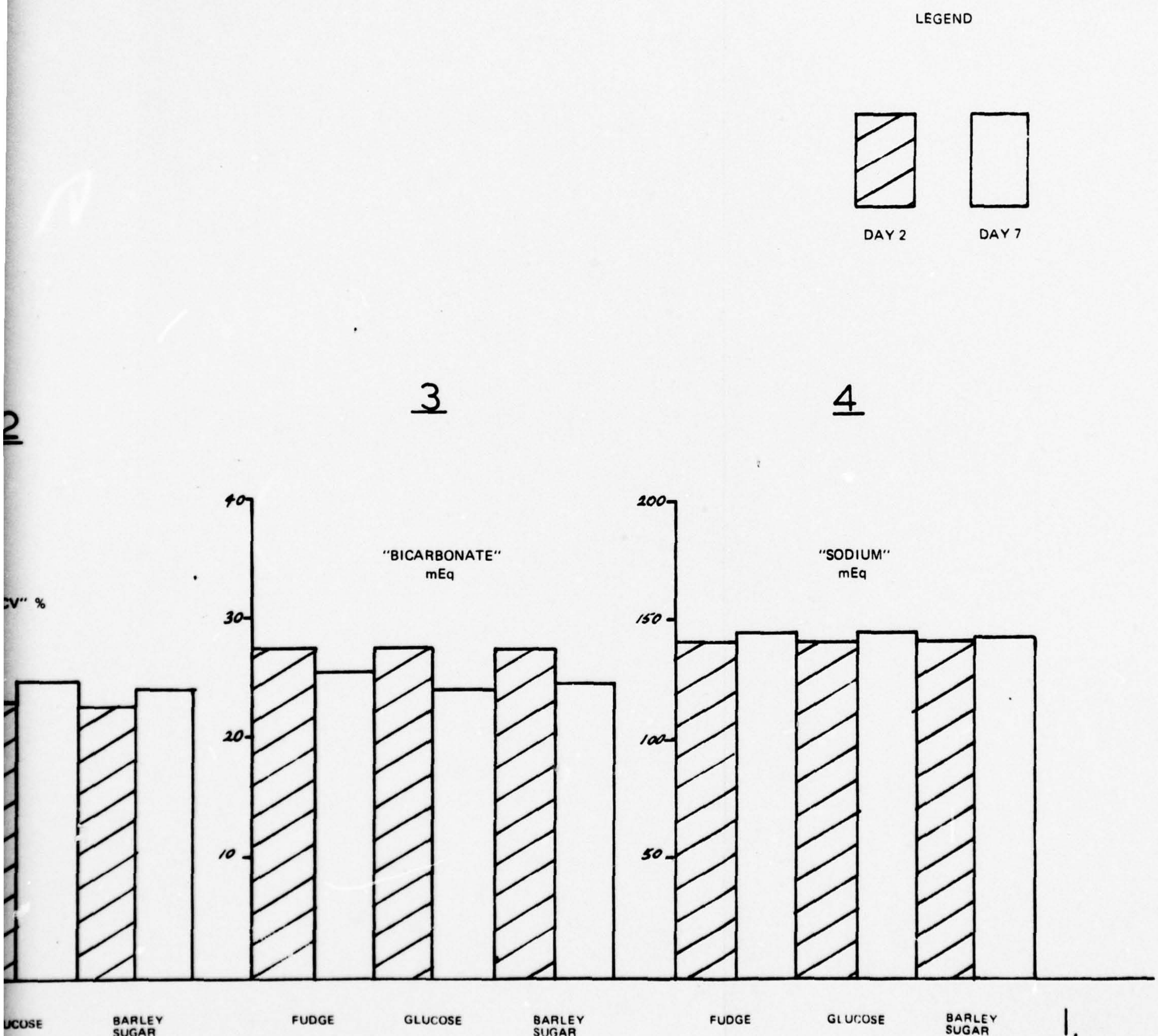
RATIONS



OPERATION – SEASPRAY

BLOOD SAMPLES – DAY 2 – DAY 7

RATIONS



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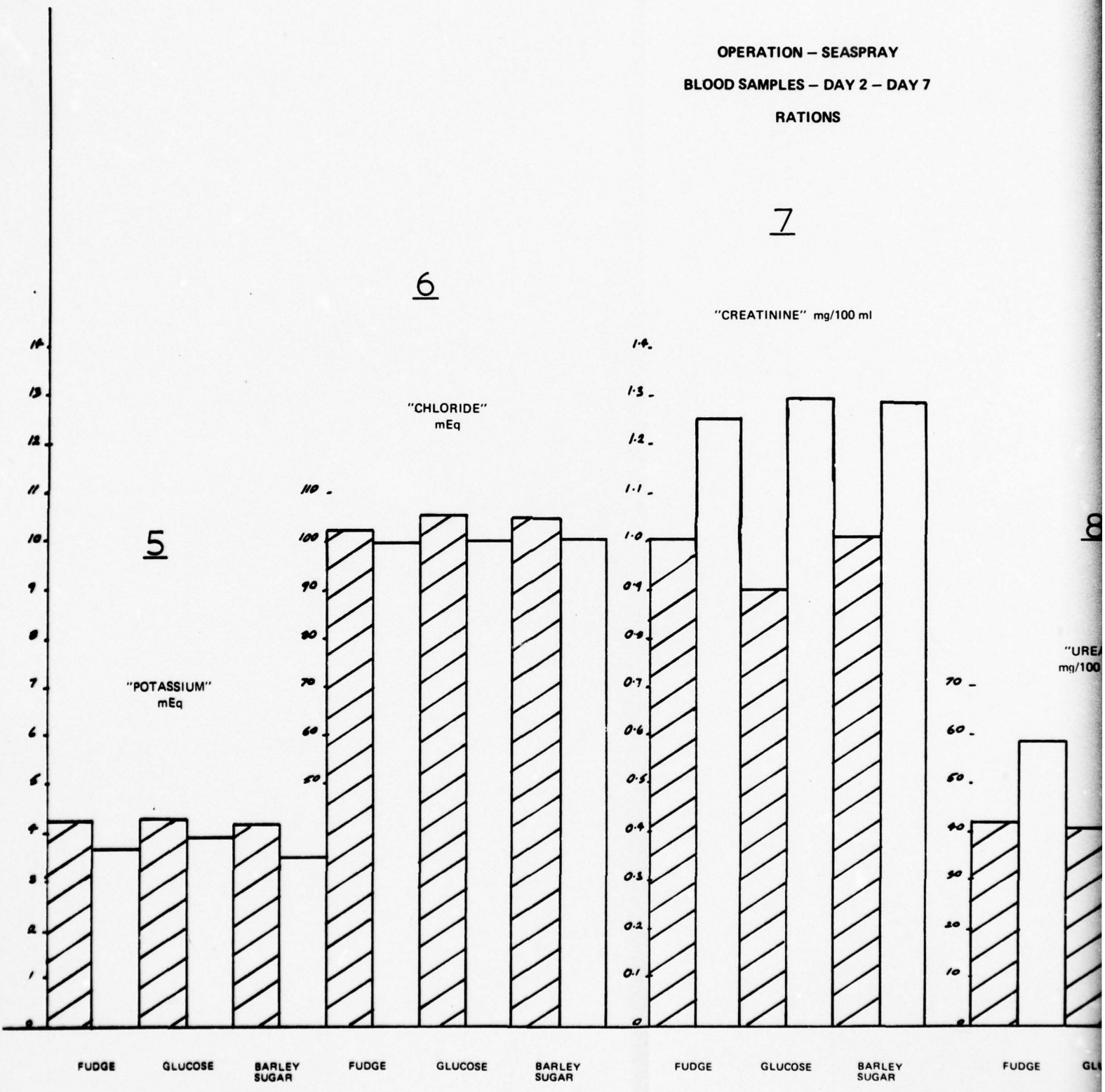
OPERATION – SEASPRAY

BLOOD SAMPLES – DAY 2 – DAY 7

RATIONS



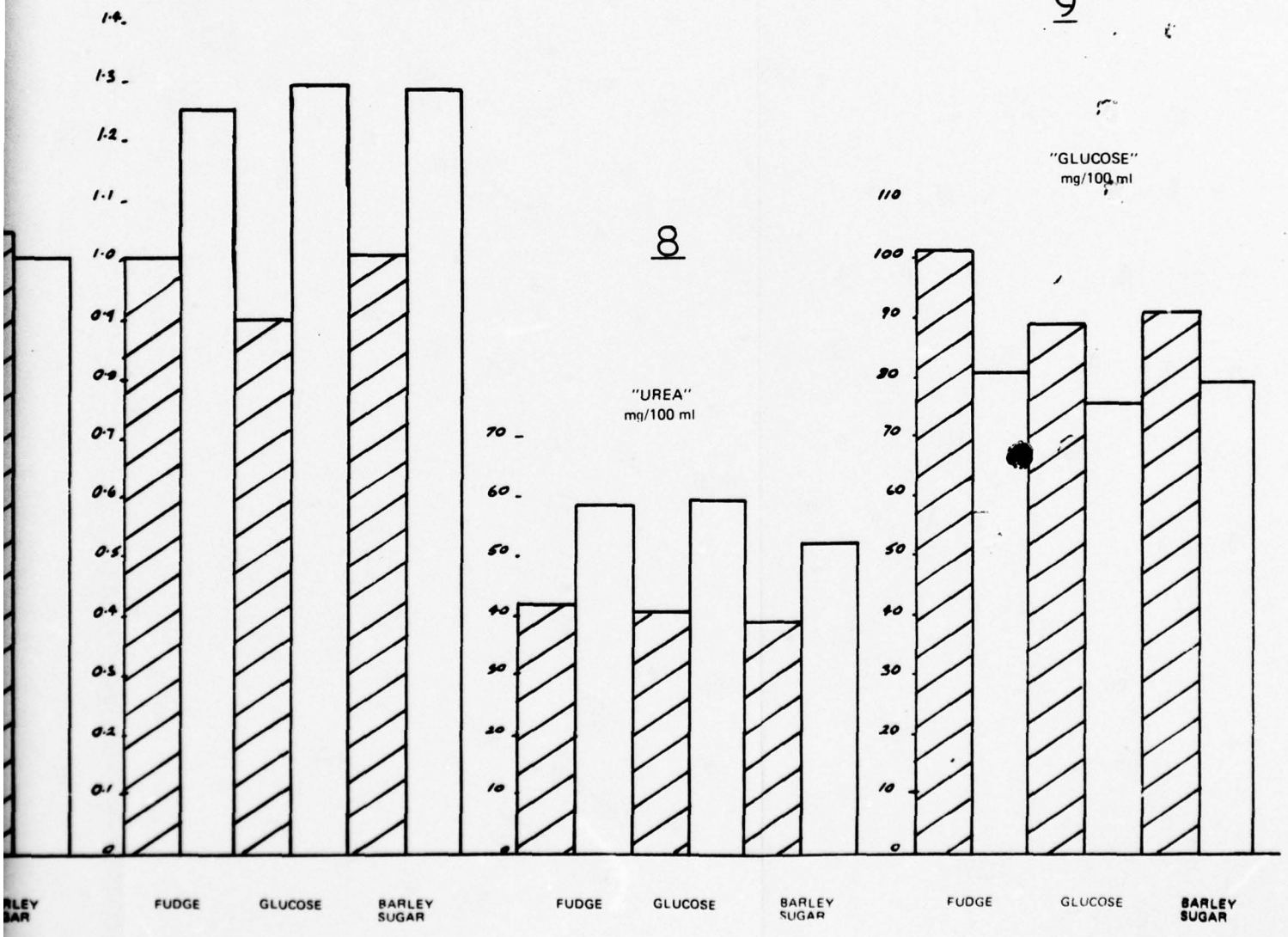
OPERATION – SEASPRAY

BLOOD SAMPLES – DAY 2 – DAY 7

RATIONS

7

"CREATININE" mg/100 ml



8

"UREA" mg/100 ml

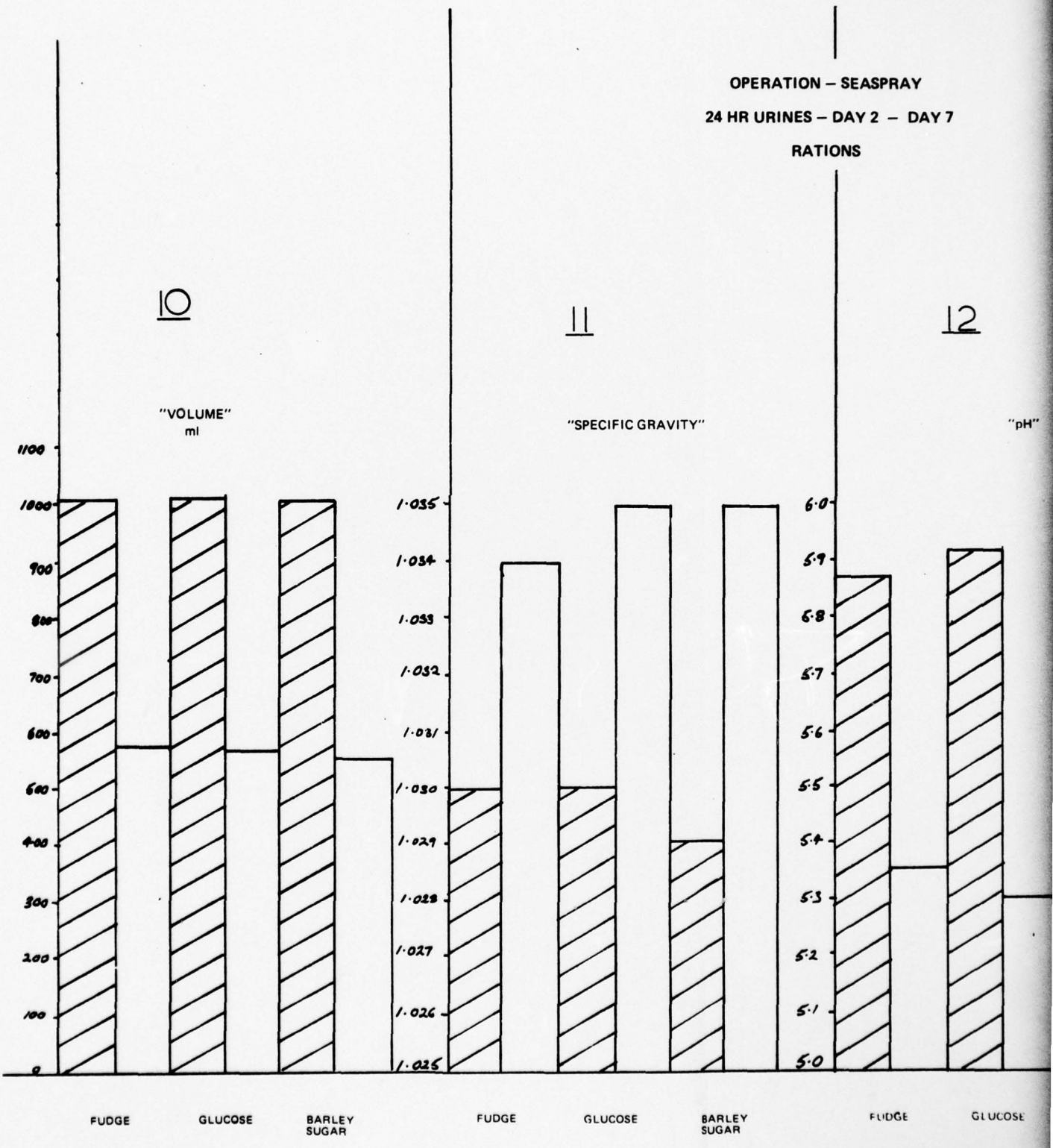
9

"GLUCOSE" mg/100 ml

OPERATION – SEASPRAY

24 HR URINES – DAY 2 – DAY 7

RATIONS

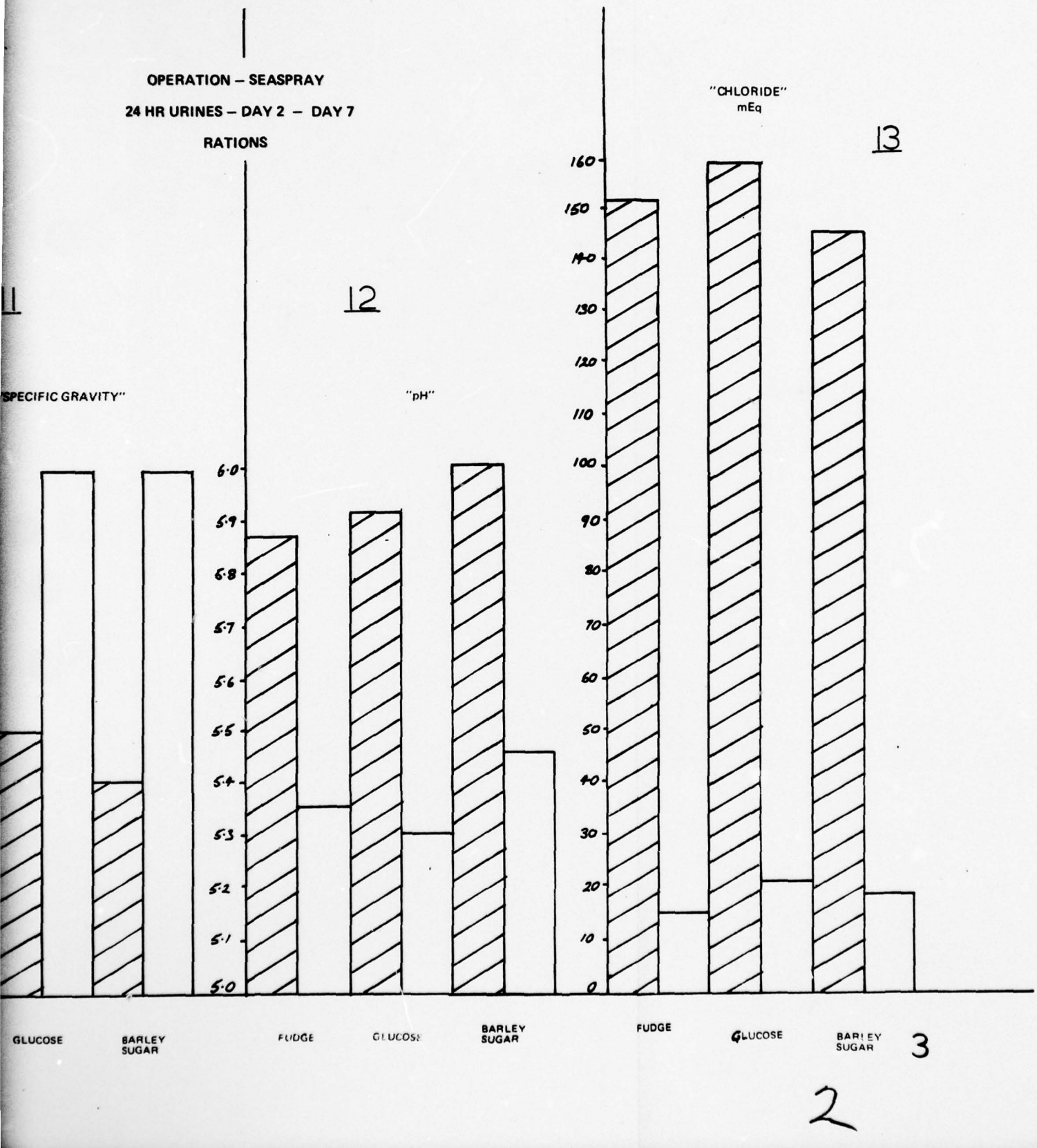


C-8

OPERATION – SEASPRAY

24 HR URINES – DAY 2 – DAY 7

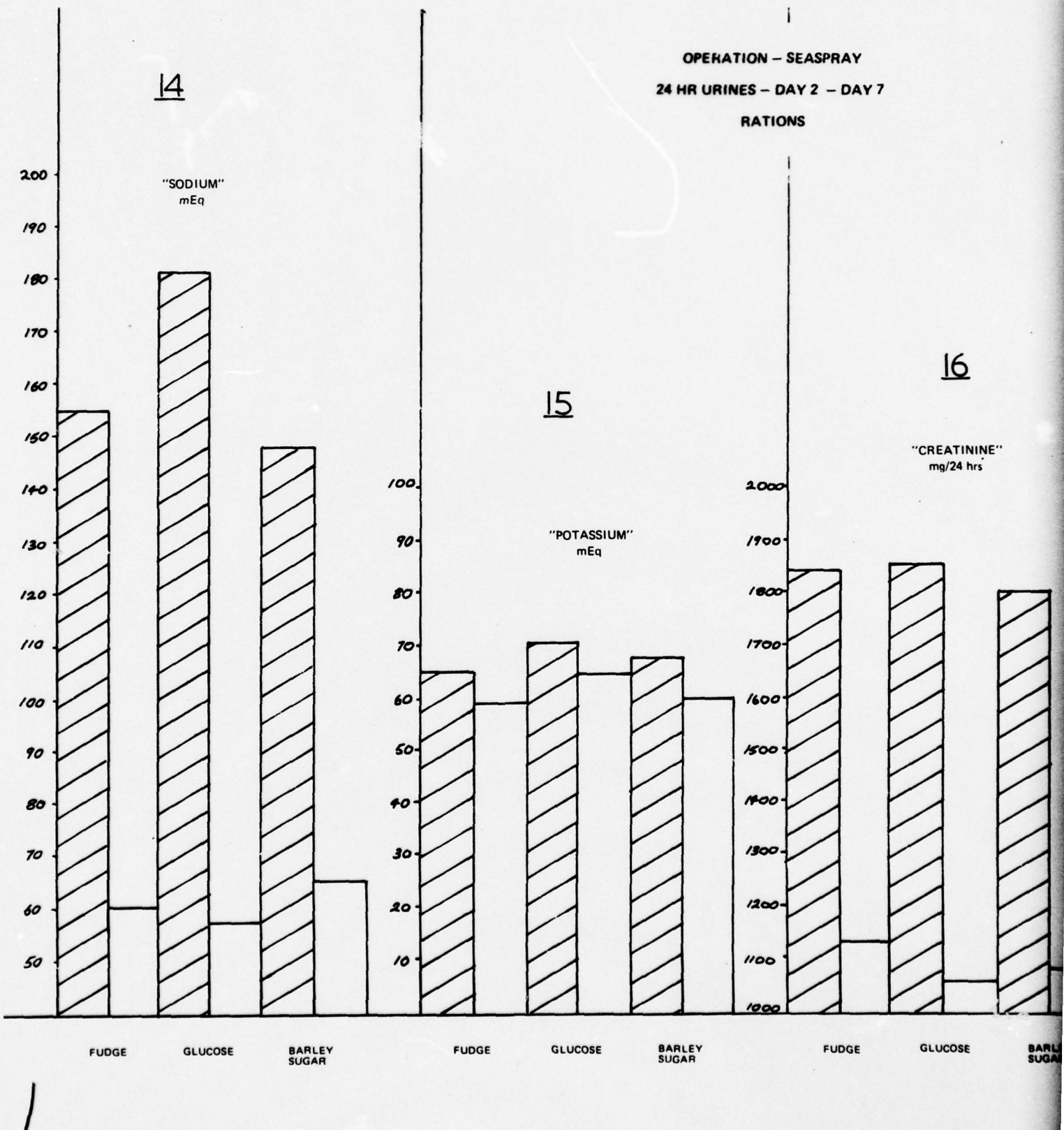
RATIONS



OPERATION – SEASPRAY

24 HR URINES – DAY 2 – DAY 7

RATIONS



C-9

OPERATION – SEASPRAY

24 HR URINES – DAY 2 – DAY 7

RATIONS

16

"CREATININE"
mg/24 hrs

2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000

17

"UREA"
mg/100 ml

240
230
220
210
200
190
180
170
160
150
140

FUDGE
GLUCOSE
BARLEY SUGAR
FUDGE
GLUCOSE
BARLEY SUGAR

ANNEX D

MEDICAL AND PHYSIOLOGICAL ASPECTS

SUMMARY

1. Daily medical and physiological observations were made on 54 young men before, during and after four days of subsistence on survival rations in liferafts moored in Darwin Harbour. For the first 24 hours in the rafts nothing was eaten or drunk. Thereafter the men drank 500 ml/day of fresh water and ate 125 g/day of the three kinds of survival ration being tested, namely barley sugar, glucose tablets and fudge.

2. The men completed the trial in good physical condition although signs of strain were apparent. On the average they lost 6.2% (4.55 kg) of their body weight, skinfold thickness decreased by 0.4 mm on the arm and by 1.0 mm on the back, and the heart rate counted while standing increased from 85 to 116 beats/min. No consistent changes occurred in oral temperature, or in the heart rate counted while lying down.

3. No significant differences in any physiological response were observed between rations, but raft and service groups differed significantly among themselves in heart rate. Differences of micro-climate between rafts were small, but the unshaded tent in which the subjects were examined each morning became progressively hotter as successive raft crews occupied it, and this heat stress seems the most likely cause of the observed differences in heart rate.

4. Observations of the micro-climate within the liferafts showed that the raft canopy greatly reduced the radiant heat to which the subjects were exposed. However, the canopy also caused a decrease of 80% in air movement and an increase in the air temperature and humidity, all of which increased the heat stress in the raft. Whether this increase was balanced or outweighted by the reduction in radiant heat has yet to be determined.

INTRODUCTION

5. Operation Seaspray, a field trial of three kinds of liferaft survival ration, was conducted at Darwin in September 1973. Its general features have been described elsewhere (RANTAU, 1974). In the present report certain medical and physiological aspects of the trial are described.

METHOD

6. The subjects, who were Army and Navy personnel from the southern states of Australia, flew from Sydney to Darwin. When not in the liferafts they lived in the Darwin RAAF Barracks, where they underwent medical and physiological examinations on the mornings of Day 1 and Day 2 of the trial. The observations on Day 2 (only) were made after an overnight fast. On Day 3 and on all subsequent days except Day 8, the examinations were made in the 'medical tent' at the trial site on the east arm of Darwin Harbour.

7. After being examined on Day 3 the subjects boarded the four liferafts (Rafts A, B, C and D), which were towed out to their moorings some 400 metres offshore. The men remained in the rafts, living on survival rations, for the next four days (the 'afloat phase', days 3-6 inclusive), except for an hour spent ashore each morning during the daily medical examinations. After the medical examinations on Day 7 the subjects resumed normal diet and returned to the RAAF Barracks, where the final medical examinations were made on Day 8. On Day 9 they flew back to Sydney.

Procedure

8. Medical and physiological observations. The medical and physiological observations reported here were made on every day of the trial. Before the observations the crew of each raft waited in the shade outside the medical tent (or hut) until each man's turn came. He then entered the tent and his skinfold thickness was measured. He sat down and completed a questionnaire, after which he was weighed. He then resumed his seat and sat quietly, without talking, for several minutes. Finally his oral temperature and heart rate was measured, clinical observations and symptoms were recorded, and he returned to the shade outside to await re-embarkation.

9. Skinfold thickness was measured at the standard left triceps and left subscapular sites, using a Harpenden skinfold caliper in the manner described by Tanner (1959). Three measurements at each site were recorded and averaged.

10. Body weight in bathing trunks, after urinating, was measured using a platform type beam balance accurate to 1 oz (28 g). The balance was carefully levelled, was shielded from wind, and was calibrated before and after the trial by the Commonwealth Bureau of Weights and Measures, Darwin.

11. Oral temperature, heart rate, and clinical observations were recorded using a standardized procedure. The subject lay down on an examination couch, a calibrated clinical thermometer was placed under his tongue, and a stopwatch was started. Clinical observations, including skin turgor and colour, and the presence or absence of oedema, were then made. After two minutes the oral temperature was recorded, and after three minutes the radial pulse (hereafter referred to as the 'lying heart rate') was counted for 30 seconds. The subject then stood up and remained standing without touching any support for one minute, after which his radial pulse (the 'standing heart rate') was again counted for 30 seconds. Finally his mouth was examined for the presence of dryness, ulcers, and other signs, and any outstanding symptoms were recorded.

12. The micro-climate within the medical tent or hut was assessed hourly or more frequently by measurements of globe thermometer temperature using a 6" diameter blackened globe, and of wet-bulb and dry-bulb air temperature using a sling psychrometer (Bedford, 1946). Air movement was estimated or was measured with a vane anemometer. Wet-bulb globe temperature (WBGT) was calculated by multiplying the wet-bulb temperature by 0.7 and the globe temperature by 0.3 and adding the results together (Yaglou and Minard, 1957).

13. Weather and micro-climate. Three-hourly observations of the weather at the trial site, and of the micro-climate within each raft and between the rafts, were made from Day 2 to Day 7 by officers of the Darwin office of the Commonwealth Bureau of Meteorology.

14. A Stevenson screen was set up and equipped on the beach opposite the rafts. The instruments used on shore were naturally-ventilated wet-bulb and dry-bulb thermometers, maximum and minimum thermometers, a recording anemometer, a thermohygrograph, a rainfall recorder, and a globe thermometer well exposed to the sun. Inside the rafts globe temperature was measured by a 6" blackened globe thermometer permanently suspended from the canopy, wet-bulb and dry-bulb air temperatures were measured with a sling psychrometer, and air movement over a 2-minute period was measured over the open water between the rafts, but air movements, wet-bulb temperature and dry-bulb temperature was measured there in the same way as inside the rafts, the psychrometer being shielded from the sun in the daytime by the observer's body. Sea temperature was recorded at the same time.

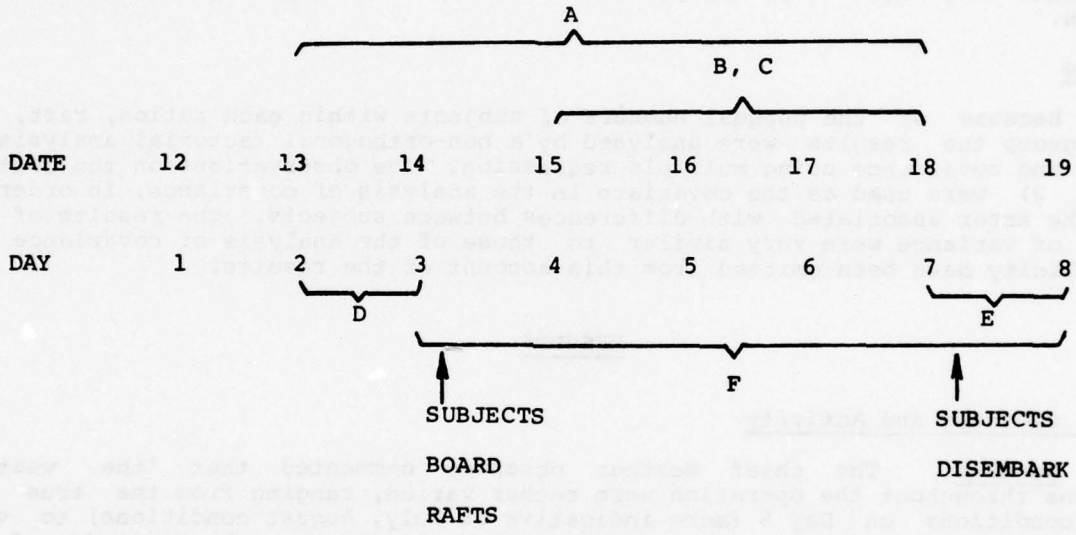
Analysis of Results

15. Differences of micro-climate between rafts and between days were assessed by a two-factor analysis of variance (Snedecor, 1961) on the means of each day's observations.

16. Differences of physiological response between rations, between rafts, and between services, and the interactions between these factors, were examined by a factorial analysis of variance and covariance, with the generous help of Dr. J. Robinson and Mr. R. Redford of the Department of Mathematical Statistics, University of Sydney.

17. Functions analysed. The analyses of the physiological observations were done on six functions derived in the manner shown in Fig. 1. The first three functions measure the subjects' response to the period spent on the rafts. Function A is the change from the control day (Day 2) to the disembarkation day (Day 7). Functions B and C are the linear and the quadratic slope, respectively, of the observations made on Days 4, 5, 6 and 7: they reflect the rate of change of the physiological responses measured.

FIG. 1 ANALYSIS OF FUNCTIONS



18. Function D measures changes occurring during the control period: it is the difference between the fasting observations of the control day (Day 2) and the nonfasting observations of the day (Day 3) the subjects boarded the rafts. The remaining two functions reflect the subjects' recovery from the period spent in the rafts. Function E is the difference between Day 8 and Day 7, and it shows the extent to which the subjects recovered in the first day after disembarkation. Function F is the difference between the nonfasting observations made immediately before boarding (Day 3) and the nonfasting observations made one day after disembarkation (Day 8), and it reflects the residual changes remaining at the end of the trial. It can be seen from Fig. 1 that the sum of Function A and E is algebraically equivalent to the sum of Functions D and F.

Subjects

19. Fifty-seven subjects began the trial, but three withdrew because of seasickness and anxiety about 30 hr after boarding the rafts. Of the 54 subjects who completed the trial, 17 ate glucose, 19 ate barley sugar, and 18 ate fudge. There were 15 subjects each in Rafts A and B, 14 in Raft C and 10 in Raft D. Twenty-six subjects were soldiers and 28 were sailors. Within each combination of raft, service and ration there were initially 2 or 3 men, but three of the combinations were left with only one man each after the three casualties had withdrawn.

Technique

20. Because of the unequal numbers of subjects within each ration, raft, and service group the results were analysed by a non-orthogonal factorial analysis of variance and covariance using multiple regression. The observations on the control day (Day 2) were used as the covariate in the analysis of covariance, in order to reduce the error associated with differences between subjects. The results of the analysis of variance were very similar to those of the analysis of covariance and for simplicity have been omitted from this account of the results.

RESULTS

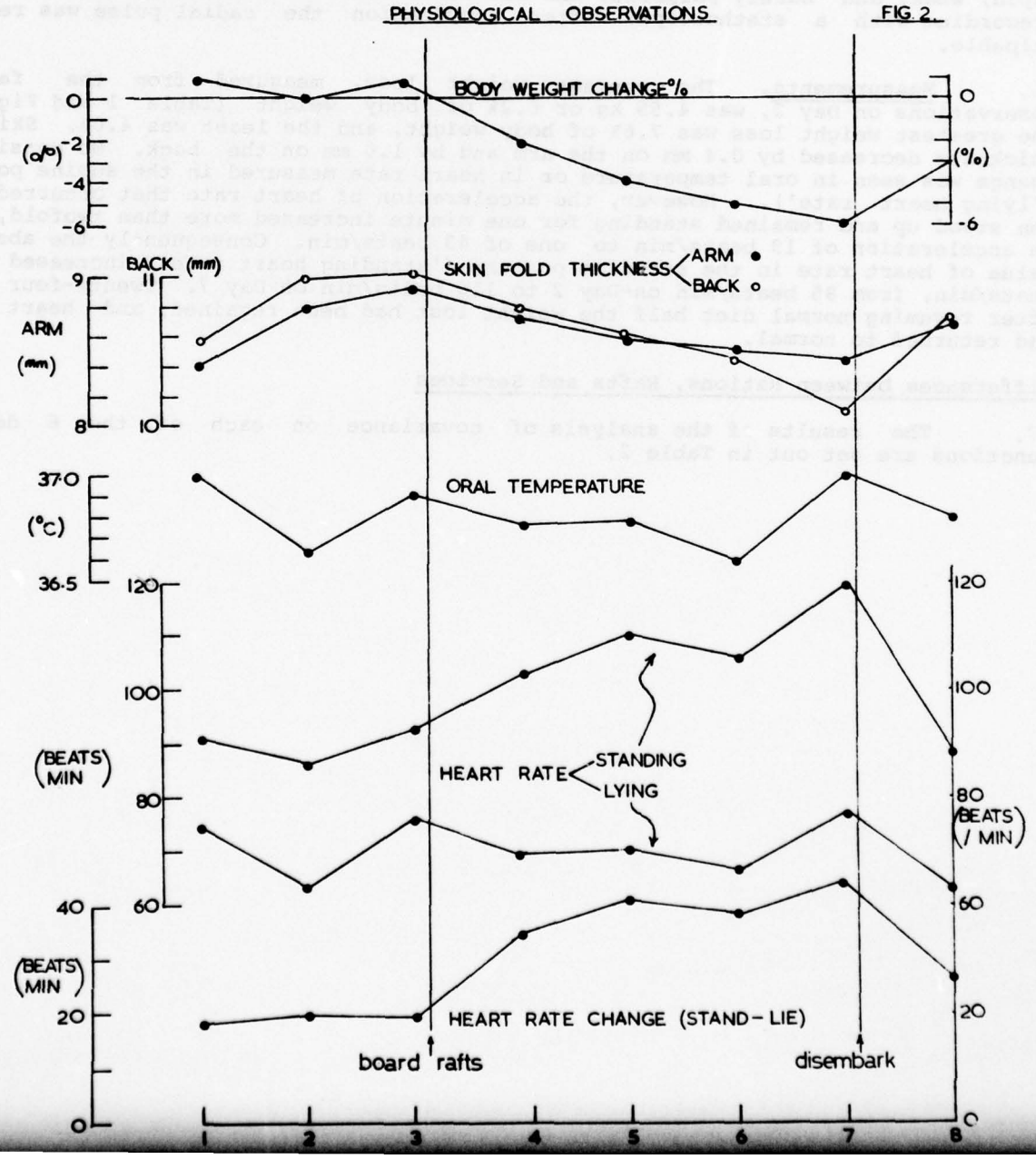
Weather, Clothing and Activity

21. Weather. The chief weather observer commented that 'the weather conditions throughout the operation were rather varied, ranging from the true dry season conditions on Day 5 (more indicative of July, August conditions) to very humid pre-wet conditions with local thunderstorm activity over the remainder of the period (indicative of October conditions). Temperatures with the exception of the brief cool dry spell were generally a little above normal for September'. Showers fell in the early morning and evening of Day 4. On Days 4 and 5 a fresh breeze at the rafts raised a choppy sea, especially around Rafts A and B which, as the very low tides on those days showed, were moored in shallower water than the other rafts.

22. Clothing. Clothing worn during the day varied from raft to raft. In Rafts B and D most men wore shirts, in Raft C most wore long trousers, and the remainder wore only bathing trunks. In each raft except Raft D a few men wet their shirts for coolness, especially when sitting in the sun at the raft entrance. At night men donned shirts and long trousers for protection against mosquitoes.

Table 1. Mean values of body weight, skinfold thickness, oral temperature and heart rate before (Day 2) and after (Day 7) the period afloat

Variable	Day 2	Day 7	Difference (7-2)
Body weight (kg)	72.95	68.40	- 4.55
(% change)	100.00	93.76	- 6.24
Skinfold thickness (mm)			
Arm	8.85	8.41	- 0.44
Back	11.04	10.04	- 1.00
Oral temperature (C)	36.66	36.91	+ 0.25
Heart rate (beats/min)			
Lying	65.9	72.8	+ 6.9
Standing	84.9	115.5	+ 30.6
Change (Standing-Lying)	19.0	42.7	+ 23.7



23. Activity. In the rafts, the men sat or lay about, sleeping, talking, reading and playing cards. A few intermittently sat in the open air at the raft entrance. Around midnight on the third and fourth evenings in the rafts (Day 5 and Day 6) the crew of Raft B deflated the canopy and lay on top of it in the open for a few hours, to obtain relief from the oppressively hot and humid conditions inside the raft.

Medical and Physiological Responses

24. Clinical observations. Apart from the three men who voluntarily withdrew from the trial some 30 hours after boarding the rafts, all men completed the trial in comparatively good physical condition. They were able to walk unaided up the slope to the medical tent, and to stand still without support for 1½ minutes while their standing heart rates were counted. No clear decrease in their skin turgor at the wrist was apparent, and their tongues remained moist.

25. Nevertheless some signs of strain were apparent by the 3rd and 4th days on the rafts. Most men's faces appeared pinched and wrinkled, and their colour was sallow and sometimes ashen or greyish. Many breathed deeply when standing still and appeared to be close to fainting. One man felt dizzy and nauseated and had to sit down when he was kept standing still for more than the usual 1½ minutes because the observer was having difficulty in finding his radial pulse. The pulse was rapid, weak, and barely palpable, and his heart rate was eventually counted at the precordium with a stethoscope; after rehydration the radial pulse was readily palpable.

26. Measurements. The average weight loss, measured from the fasting observations on Day 2, was 4.55 kg or 6.2% of body weight (Table 1 and Fig. 2). The greatest weight loss was 7.6% of body weight, and the least was 4.0%. Skinfold thickness decreased by 0.4 mm on the arm and by 1.0 mm on the back. No consistent change was seen in oral temperature or in heart rate measured in the supine posture ('lying heart rate'). However, the acceleration of heart rate that occurred when men stood up and remained standing for one minute increased more than twofold, from an acceleration of 19 beats/min to one of 43 beats/min. Consequently the absolute value of heart rate in the standing posture ('standing heart rate') increased by 31 beats/min, from 85 beats/min on-Day 2 to 116 beats/min on Day 7. Twenty-four hours after resuming normal diet half the weight lost had been regained, and heart rate had returned to normal.

Differences between Rations, Rafts and Services

27. The results of the analysis of covariance on each of the 6 derived functions are set out in Table 2.

Table 2. Analysis of covariance. Summary of significance tests for each function.

Function A. Final ration day (7) minus control day (2)

Source of variation	BW	SFA	SFB	Temp	HRL	HRS	S-L
Rations	-	-	-	-	-	-	-
Rafts	-	*	-	-	**	*	-
Services	-	-	-	-	*	**	-
Rations x rafts	-	-	-	-	-	-	-
Rations x services	-	-	-	-	-	-	-
Rafts x services	-	-	-	-	-	-	-
Rations x rafts x services	-	-	-	-		-	-

Function B. Linear Slope, days 4-7

Source of variation	BW	SFA	SFB	Temp	HRL	HRS	S-L
Rations	-	-	-	-	-	-	-
Rafts	-	-	-	-	-	*	-
Services	-	-	-	-	-	*	-
Rations x rafts	-	-	-	-	-	-	-
Rations x services	-	-	-	-	-	-	-
Rafts x services	-	-	*	-	-	-	-
Rations x rafts x services	-	-	-	-	-	-	-

Function C. Quadratic slope, days 4-7

Source of variation	BW	SFA	SFB	Temp	HRL	HRS	S-L
Rations	-	-	-	-	-	-	-
Rafts	*	-	-	*	-	*	-
Services	-	-	-	-	-	-	-
Rations x rafts	-	-	-	-	-	-	-
Rations x services	-	-	-	-	-	-	-
Rafts x services	-	-	-	*	-	*	*
Rations x rafts x services	-	-	-	-	-	-	-

Function D. Embarkation day (3) minus control day (2)

Source of variation	BW	SFA	SFB	Temp	HRL	HRS	S-L
Rations	-	-	-	-	-	-	-
Rafts	-	**	-	-	-	-	-
Services	-	-	-	*	-	-	-
Rations x rafts	-	-	-	*	-	-	-
Rations x services	-	-	-	-	-	-	-
Rafts x services	-	-	-	-	-	-	-

Rations x rafts x services	-	-	-	-	-	-	-

Function E. Recovery day (8) minus final ration day (7)

Source of variation	BW	SFA	SFB	Temp	HRL	HRS	S-L
Rations	**	-	-	-	-	-	-
Rafts	-	-	-	-	***	***	-
Services	*	-	-	-	-	-	-
Rations x rafts	-	-	-	-	-	-	-
Rations x services	-	-	-	-	-	-	-
Rafts x services	-	-	-	-	-	-	*
Rations x rafts x services	-	-	-	-	-	-	-

Function F. Recovery day (8) minus embarkation day (3)

Source of variation	BW	SFA	SFB	Temp	HRL	HRS	S-L
Rations	*	-	-	*	-	-	-
Rafts	*	-	*	-	-	-	-
Services	**	-	-	-	-	*	-
Rations x rafts	-	-	-	-	-	-	-
Rations x services	-	-	-	-	-	-	-
Rafts x services	-	-	-	-	-	-	-
Rations x rafts x services	-	*	-	-	-	**	-

Abbreviations used:

BW : Body weight

SFA : Skinfold thickness of arm

SFB : Skinfold thickness of back

Temp : Oral temperature

HRL : Heart rate when lying down

HRS : Heart rate when standing up

S-L : Difference between HRS and HRL

Levels of statistical significance:

* $0.05 \geq P > 0.01$

** $0.01 \geq P > 0.0001$

*** $0.001 \geq P$

\- Not signficant

Interactions

28. Eight of the 192 interactions tested were significant, seven of them at the 5% level and one at the 1% level. The interpretation of this finding is uncertain because as many as ten apparently significant results at the 5% level, or two at the 1% level, are to be expected from chance alone when 192 significance tests are made.

Differences between Rations

29. There were no significant differences between rations (Tables 3 and 4), except for body weight and oral temperature in the recovery period, when the fudge group regained 0.3 kg more weight than the glucose group and 0.5 kg more than the barley sugar group. This difference was reflected in a slightly smaller difference in body weight between Days 8 and 3 for the fudge group than the other groups. The difference in oral temperature, although significant, was very small (0.1 C).

Table 3. Ration effects - significance tests ≠

Variable	Function					
	A	B	C	D	E	F
Body weight	-	-	-	-	**	*
SFA	-	-	-	-	-	-
SFB	-	-	-	-	-	-
Temp	-	-	-	-	-	*
HRL	-	-	-	-	-	-
HRS	-	-	-	-	-	-
HR (S-L)	-	-	-	-	-	-

≠ Abbreviations and symbols as for Table 2

Table 4. Ration effects - significant mean values ≠

Function	Variable	P	Ration		
			Glucose	Barley Sugar	Fudge
E (days 8-7)	Body weight (kg)	**	2.34	2.15	2.67
F (days 8-3)	Body weight (kg)	*	- 2.75	- 2.66	- 2.31
	Oral temperature (C)	*	- 0.11	- 0.07	- 0.24

≠ Abbreviations and symbols as for Table 2.

Differences between Rafts

30. There was significant differences between rafts in several variables, of which the most striking were those of heart rate (Tables 5 and 6). During the afloat phase, lying and standing heart rate increased more for rafts C and D than for rafts A and B, and conversely decreased more on Day 8 as heart rates returned to normal levels. Rafts did not differ signficantly in the extent to which heart rate accelerated when men stood up.

Table 5. Raft effects - significance tests ≠

Variable	Function					
	A	B	C	D	E	F
Body weight	-	-	*	-	-	*
SFA	*	-	-	**	-	-
SFB	-	-	-	-	-	*
Oral temperature	-	-	*	-	-	-
HRL	**	-	-	-	***	-
HRS	*	*	*	-	***	-
HR (S-L)	-	-	-	-	-	-

≠ Abbreviations and symbols as for Table 2.

Table 6. Raft effects - significant mean values ≠

Function	Variable	P	Raft			
			A	B	C	D
A (days 7-2)	Arm skinfold (mm)	*	0.43	- 0.60	- 0.82	- 0.95
	Heart rate lying (bpm)	**	2.5	1.6	11.4	15.1
	Heart rate standing (bpm)	*	25.4	24.0	33.7	44.2
B (linear slope)	Heart rate standing (beats/min/day)	*	3.95	2.13	2.74	7.22
C (quadratic slope)	Body weight (kg/day/day)	*	0.12	0.16	0.29	0.22
	Oral temperature (°C/day/day)	*	0.32	0.13	0.15	0.20
	Heart rate standing (bpm/day/day)	*	6.5	1.0	- 0.6	6.1
D (days 3-2)	Arm skinfold (mm)	**	1.03	0.30	- 0.49	- 0.05
E (days 8-7)	HR lying (bpm)	***	- 3.7	- 5.3	- 13.2	- 26.0
	HR standing (bpm)	***	- 20.5	- 22.1	- 32.1	- 50.0
F (days 8-3)	Body weight (kg)	*	- 2.41	- 2.35	- 3.06	- 2.47
	Back skinfold (mm)	*	- 0.58	- 0.28	- 0.04	- 1.06

≠ Abbreviations and symbols as for Table 2.

Differences between Services

31. The main significant differences between services were those of heart rate (Tables 7 and 8). During the afloat phase, lying and standing heart rates were higher for Navy subjects than for Army ones. The acceleration of heart rate when men stood up tended to be greater for the Navy subjects than for the Army ones, but the difference was not significant.

Table 7. Service effects - significance tests ≠

Variable	Function					
	A	B	C	D	E	F
Body weight	-	-	-	-	*	**
SFA	-	-	-	-	-	-
SFB	-	-	-	-	-	-
Oral temperature	-	-	-	*	-	-
HRL	*	-	-	-	-	-
HRS	**	*	-	-	-	*
HR (S-L)	-	-	-	-	-	-

≠ Abbreviations and symbols as for Table 2.

Table 8. Service effects - significant mean values ≠

Function	Variable	P	Service	
			Navy	Army
A (days 7-2)	Heart rate lying (beats/min)	*	13.0	0.3
	Heart rate standing (beats/min)	**	38.6	22.1
B (linear slope)	Heart rate standing (bpm/day)	*	4.67	2.73
D (days 3-2)	Oral temperature (^{o}C)	*	0.27	0.20
E (days 8-7)	Body weight (kg)	*	2.26	2.51
F (days 8-3)	Body weight (kg)	**	- 2.79	- 2.33
	Heart rate standing (bpm)	*	- 4.5	- 10.2

≠ Abbreviations and symbols as for Table 2.

bpm : beats/min

Micro-climate experienced during Daily Medical Examinations

32. The daily medical examinations were made in an unlined aluminium hut at the RAAF Barracks on Days 1, 2 and 8, and in a tent at the beach on the other days. Neither the hut nor the tent was air-conditioned, insulated, or shaded, and the tent did not have a fly sheet. Consequently the indoor conditions reflected, and usually exaggerated, the outdoor weather. Mean WBGT during each day's medical examinations ranged from 26.0 C to 29.3 C and averaged 27.2 C. The day-to-day variations of WBGT are remarkably similar to those of heart rate and oral temperature (Fig. 3), a finding which suggests that any effects that dehydration might have had on heart rate and oral temperature were outweighed by the effects of the thermal environment in which the examinations were made.

FIGURE 3

SELECTED PHYSIOLOGICAL OBSERVATIONS

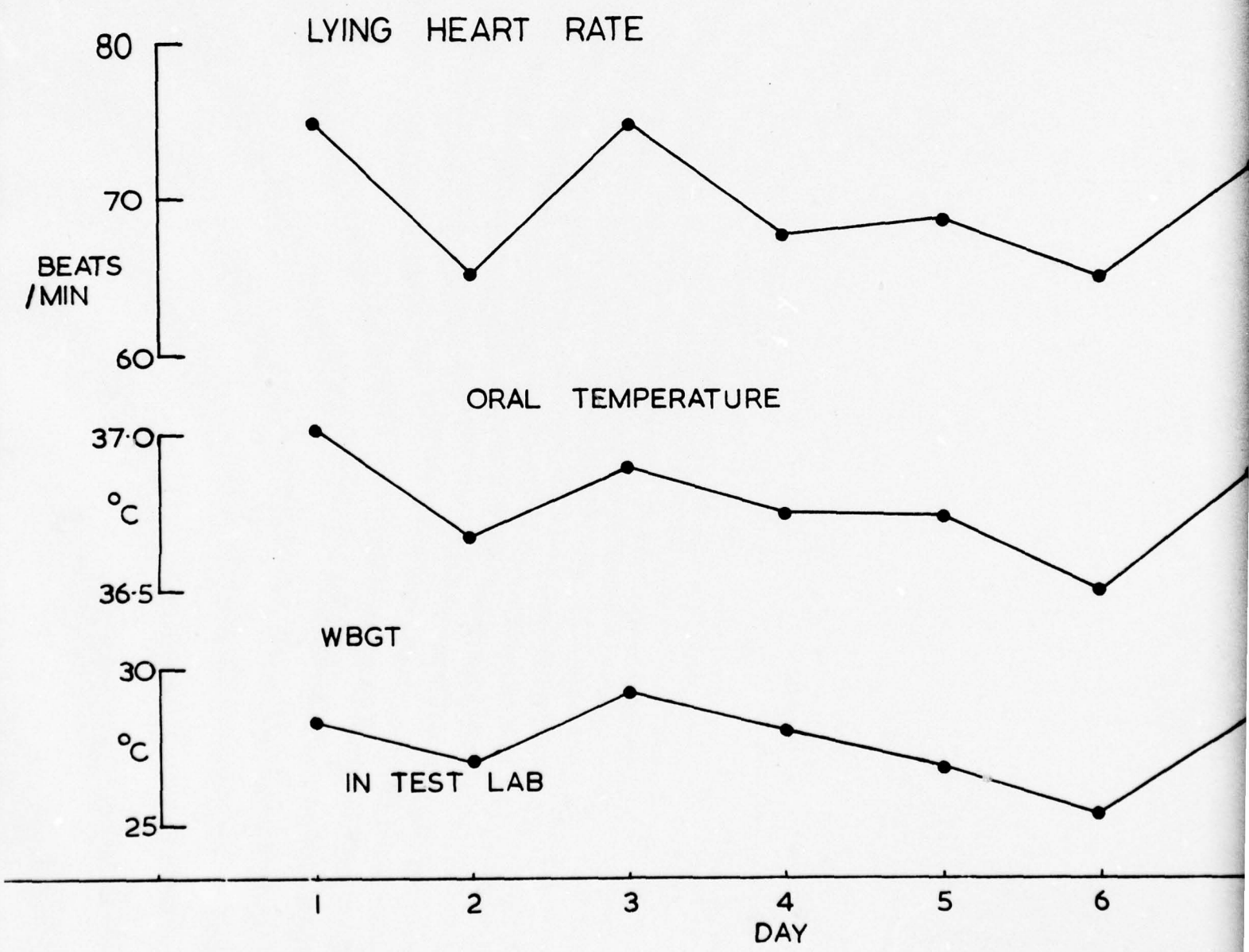
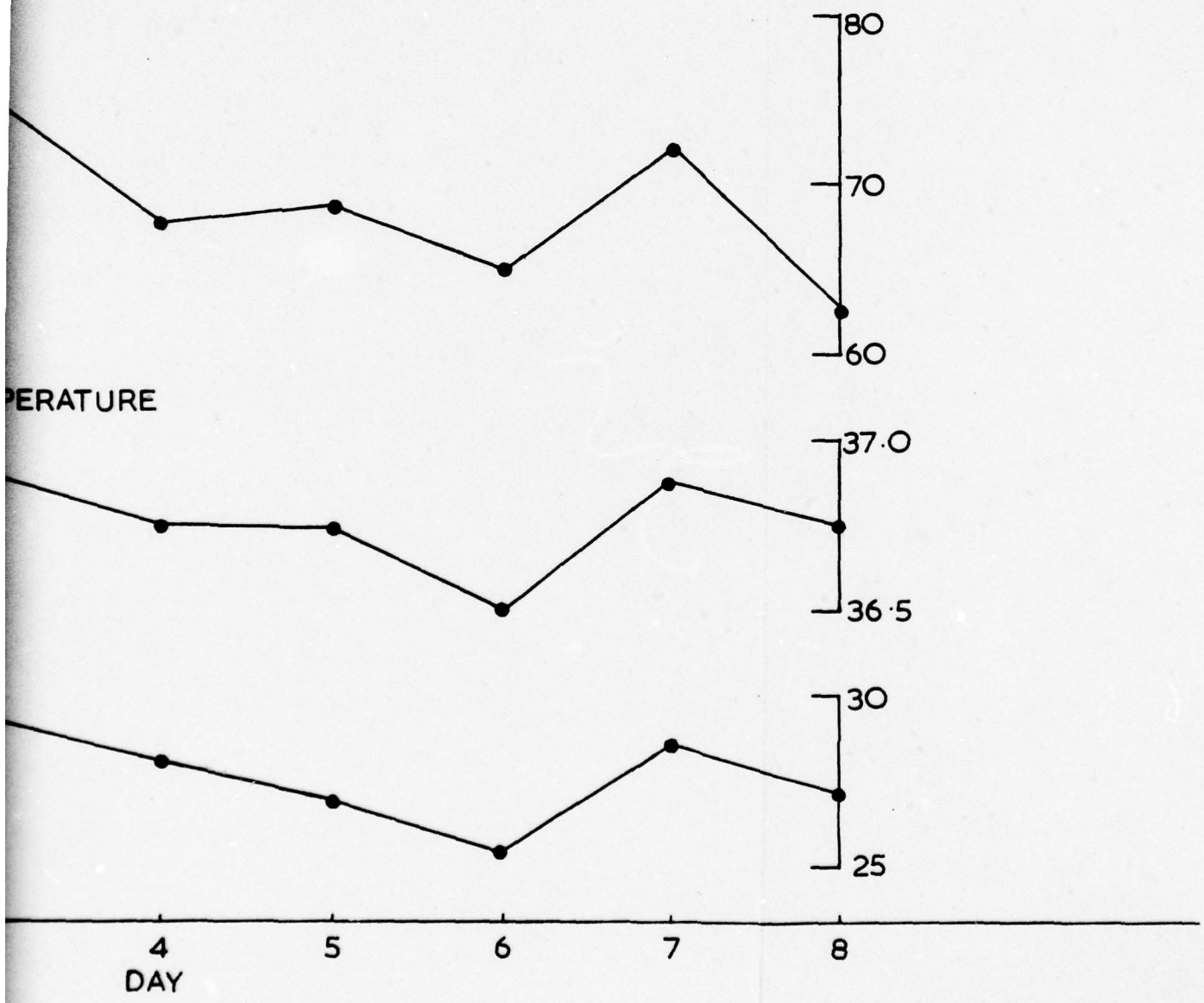


FIGURE 3

PHYSIOLOGICAL OBSERVATIONS



2

Differences between Rafts and between Services

33. On each day raft crews were examined between 0800 hr and 1200 hr in the order Raft A, B, C, and D, and within each raft crew the Army men were examined before the Navy men. Thus each raft crew and service group experienced a different micro-climate from the others as the day grew warmer. During the medical examinations on Day 3 for example (Fig. 4), globe temperature inside the tent rose from 31 C to 41 C, air temperature rose from 29 C to 37 C, water vapour pressure rose from 25 to 29 mb, and WBGT rose from 27 C to 30 C. An increase in air movement from 0.3 to 0.5 m/sec provided a little relief, but stronger breezes had to be excluded by closing the tent flap because they would have made the weighing machine inaccurate. Figure 5 shows the marked differences between the micro-climates experienced by each raft crew during its medical examinations throughout the trial; analysis of variance showed that the differences between rafts, and between days, were highly significant ($P<0.001$). On each day the crews of Rafts C and D experienced hotter conditions during the medical examinations than did the crews of Rafts A and B, and this seems very likely to have contriubted to the higher heart rates observed in Rafts C and D. That the Navy men had higher heart rates and oral temperatures than the Army men might also be partly due to their having been examined half an hour later, and hence in warmer conditions, than the Army men.

FIGURE 4
RAFT ENVIRONMENT

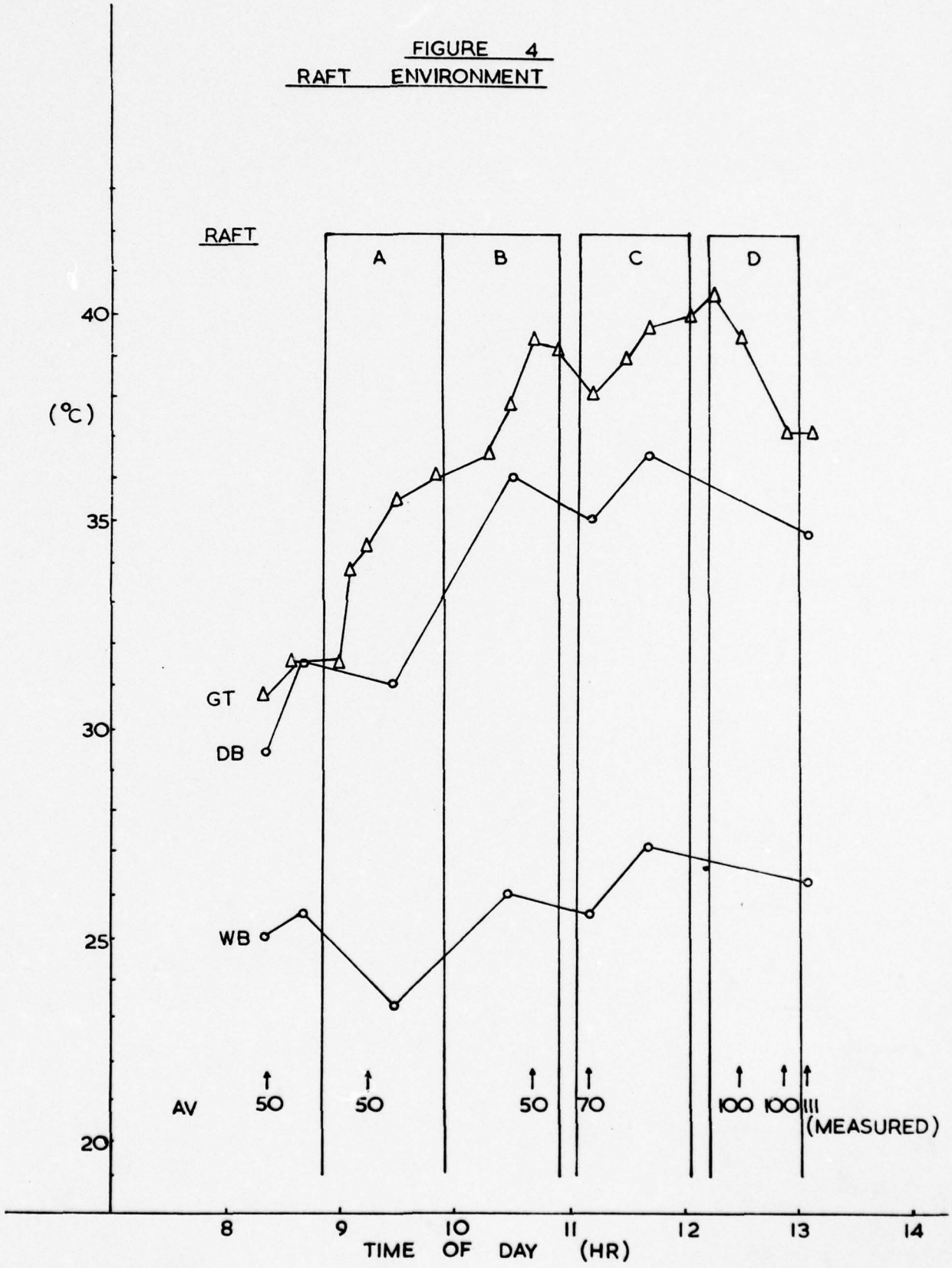
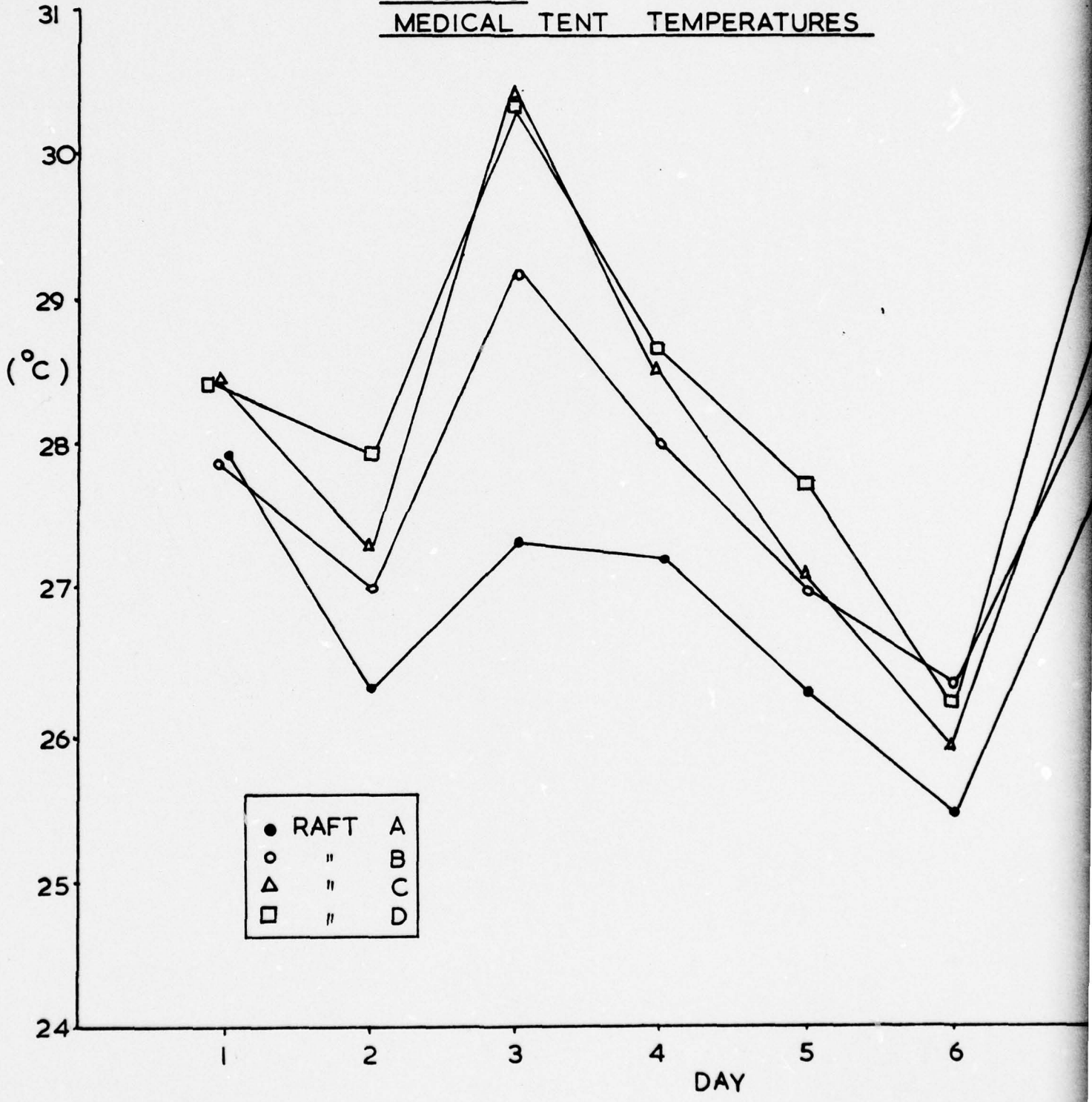
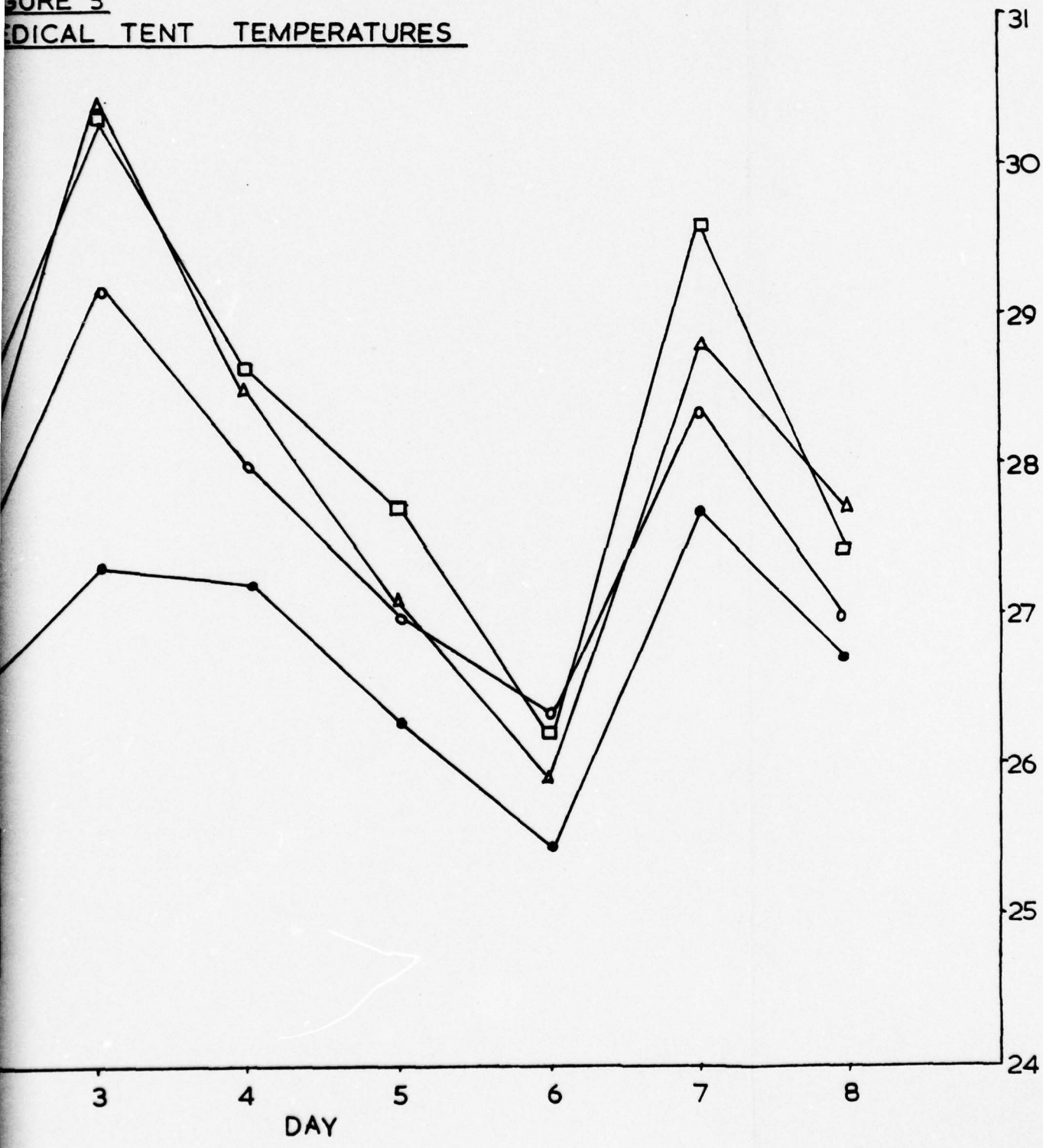


FIGURE 5
MEDICAL TENT TEMPERATURES



GURE 5
EDICAL TENT TEMPERATURES



2

34. It is pertinent to mention here another factor that would have contributed to the observed differences of heart rate and oral temperature between rafts and between services, namely the normal circadian rhythm of these variables. Between 0800 hr and 1200 hr this factor might be expected to have caused increases of about 0.4 C in oral temperature (Adam & Ferres, 1954; Palmai, 1962) and 10 beats/min in heart rate (Kleitman & Ramsaroop, 1948; Tanner, 1951).

Micro-climate of Rafts

35. *Average conditions.* Table 9 shows that average conditions of weather and micro-climate during the 4 days that the rafts were occupied. Air temperature and humidity were slightly higher over the water ('between rafts') than they were on shore, and slightly higher again inside the rafts. Windspeed was the same over the water as it was on shore, but it was only one-fifth as much inside the rafts. Mean radiant temperature inside the rafts was 15 C less than it was on shore, being only 1.7 C above air temperature in the rafts as against 18.4 C above air temperature on shore. The daily range of mean radiant temperature was also much less in the rafts than on shore, being 27-40 C in the rafts and 22-80 C on shore. Sea temperature ranged from 27.4 C to 29.4 C and averaged 28.3 C.

Table 9. Raft micro-climates and weather. Mean values for the 4 days of raft occupation

	Raft				All rafts	Between Rafts	On
	A	B	C	D			
Measured variables							
Dry-bulb °C	30.2	30.5	30.3	30.3	30.3	29.4	28.8
Wet-bulb °C	25.3	25.6	25.3	25.3	25.4	24.4	23.0
Globe temperature °C	30.8	31.1	31.0	31.1	31.0	*	33.2
Windspeed m/s	0.73	0.51	0.49	0.58	0.58	3.14	3.24
Derived variables							
Dew point °C	23.4	23.8	23.4	23.5	23.5	22.4	19.5
Vapour pressure mb	28.8	29.4	28.8	29.0	29.0	27.1	22.7
Mean radiant temperature °C	31.9	31.9	32.1	32.1	32.0	*	47.2
Stress indices ≠							
WBGT °C	26.9	27.3	27.0	27.0	27.1	27.2	26.1

* Not measured. In calculating stress indices between rafts an assumed value, which made the difference between globe temperature and dry bulb the same as it was on shore, was used.

≠ WBGT : Wet-bulb globe temperature

CET : Corrected effective temperature

P4SR : Predicted 4-hr sweat rate

Indices of Heat Stress

36. The above measurements show that the raft canopy provided good protection against radiant heat, and that this was obtained at the cost of a large reduction in air movement and a small increase in air temperature and humidity, all of which served to increase the heat stress inside the raft. In an attempt to assess the combined effect of these factors, three indices of heat stress (Macpherson, 1962) were computed, namely the wet-bulb globe temperature (WBGT), the corrected effective temperature (CET), and the predicted 4-hour sweat rate (P4SR).

37. On shore the average daily WBGT was 26.9 C on Day 3 and declined to 25.3 C on Day 5, rising to 25.5 C on Day 6. WBGT inside the rafts was generally 1 C higher than on shore, and varied from about 25 C at 0600 hr to abour 29 C at 1200 hr. The rafts differed in WBGT among themselves by 0.2 - 0.6 C, Raft B being always the warmest. The overall differences between rafts in WBGT, air temperature, humidity and windspeed were not statistically significant, although individual comparisons showed that WBGT in Raft B was significantly warmer ($P<0.05$) than in Raft A, and almost significantly warmer than in Rafts C and D. These small differences seem unlikely to have been responsible for the observed differences between raft crews in heart rate, referred to earlier.

38. It was considered impractical to derive CET and P4SR for every set of weather observations because of the laboriousness of the computations. Instead these indices (together with WBGT) were calculated for the warmest and coolest conditions (as estimated by WBGT on shore) experienced during the 4 days spent afloat, namely 1200 hr on Day 3 and 0600 hr on Day 6. Raft A was assumed to be representative of the other rafts.

39. In the warmest conditions (Table 10) WBGT and CET in Raft A were only slightly cooler - by 1.4 C and 0.6 C respectively - than they were on shore, but P4SR in the raft was less than one-third of its value on shore. Besides being the most reliable of the three indices in warm conditions (Macpherson, 1962), P4SR provides a convenient estimate of sweat loss. This was 163 g/hr in Raft A and 525 g/hr on shore. That is, in one hour a man on shore would have lost as sweat more than a whole day's ration of water. From this example it would appear that in the warmest conditions the raft canopy gave valuable protection from heat, and thus conserved water by reducing the need to sweat.

Table 10. Raft micro-climate and weather in warm conditions, at 1200 hr on Day 3.

	Raft A	Between rafts	On shore
Measured variables			
Dry bulb ^{o}C	31.7	30.3	31.4
Wet bulb ^{o}C	26.3	24.7	24.0
Globe temperature ^{o}C	34.4	43.3*	44.4
Windspeed m/s	0.18	0.96	2.48
Derived variables			
Dew point ^{o}C	24	23	20
Vapour pressure mb	30.6	28.1	23.4
Mean radiant temperature ^{o}C	36.8	-	78.2
Stress indices			
WBGT ^{o}C	28.7	30.3	30.1
CET ^{o}C	28.5	29.5	29.1
P4SR kg/4 h	0.65	1.70	2.10
Water loss g/h	163	425	525

40. Conversely, in the coolest conditions (Table 11) the raft canopy protected men from what would have been an uncomfortable degree of cold stress. CET in the raft was 10.3 C higher than it was on shore, and WBGT and P4SR also appeared to show that it was warmer in the raft than on shore, although the two latter indices are not intended for use in cool conditions (Kerslake, 1972).

Table 11. Raft micro-climate and weather in cool conditions, at 0600 hr on Day 6 (Monday, 17th)

	Raft A	Between rafts	On shore
Measured variables *			
Dry bulb °C	27.3	25.6	23.8
Wet bulb °C	22.8	22.3	19.0
Globe temperature °C	26.5	25.2*	23.4
Windspeed m/s	0.1	3.17	2.29
Derived variables			
Dew point °C	21	21	16
Vapour pressure mb	24.9	24.9	18.2
Mean radiant temperature °C	26.5	-	22.0
Stress indices ≠			
WBGT °C	24.0	23.2	20.3
CET °C	24.2	15.6	13.9
P4SR kg/4 h	-0.40	-0.75	-0.90

* As for Table 9

≠ As for Table 9

DISCUSSION

41. The clinical and physiological observations reported here show that the subjects completed the trial in comparatively good physical condition. Nevertheless signs of strain were apparent, and the men's ability to cope with any additional stress was reduced. The occurrence of diarrhoea in one man on the last day afloat illustrates one such stress - a potentially disastrous one for all occupants of the raft. Other likely stresses, in a real survival situation, would be the occurrence of severe seasickness, of a period of hot windless weather leading to increased sweat loss, or simply a longer period afloat if rescue was delayed.

42. The present analysis - which did not include the biochemical changes in blood and urine, nor the circulatory responses to standard exercise, both of which are being analysed by other workers - revealed no significant differences between the three rations tested. It is of course possible that analysis of the records of the weight of uneaten rations, or of men's responses to the daily questionnaires and the debriefing questionnaire, might reveal differences in the acceptability of the various rations; and that an analysis of urine volumes and concentrations might reveal differences in the rations' effects of the conservation of water by the kidneys. However, of potentially greater significance than the rations is the micro-climate created by the raft canopy, for this affects sweat loss, which is a far more potent source of dehydration than the urinary water loss; it is considered in detail later in this discussion.

Differences between Rafts and Services

43. The finding that there were significant and substantial differences between raft crews and between services is of interest for two reasons. Firstly, it vindicates the decision to include every ration and both services within each raft. Administratively it would have been simpler to allocate a single ration, and possibly a single service, to each raft; and in any future trial in which there were marked differences between rations (for example, if one group had adequate rations and a control group had no rations at all) the problems of maintaining morale and discipline, and of ensuring that each group ate its appropriate ration throughout the trial, could well be formidable. Yet to allocate a single ration or service to each raft would be to confound the effects of rations, rafts and services, and thus to make it impossible to draw any valid conclusions about differences between the rations under test. Had such an allocation been made in the present trial the sizeable differences that were observed between rafts might well have been attributed to the rations eaten in those rafts - a false conclusion that might have lead to expensive and unnecessary changes in the liferaft rations issued to the Services.

44. Secondly, the finding that there were significant differences between the physiological responses of the various raft crews and of the two services demonstrated the value of the thorough observations that were made of the micro-climates of the rafts and the medical tent, for without these observations the physiological differences could not have been interpreted. That these physiological differences appear to have been due to the hot and variable micro-climate in the medical tent serves to emphasize the importance of providing an air-conditioned laboratory in any future trials of this nature.

Micro-climate of Rafts

45. Previous investigators of the problems of survival in liferafts have shown (Adolph, 1947) that the provision of shade can reduce evaporative water loss by as much as 36%. However, they have also pointed out (Gamble, 1944) that 'it is very important that equipment for shade should be so designed as not to obstruct breeze'.

46. The canopies of the rafts used in Operation Seaspray failed to meet this requirement, for they greatly impeded air movement. They provided excellent protection from radiant heat, but the benefit of this may well have been outweighed by the harmful effects of the associated decrease in air movement-and increase in air temperature and humidity.

47. In the single example of warm conditions for which P4SR was calculated the canopy appeared to confer a distinct advantage in that the estimated sweat loss was reduced by two thirds, but it is not known to what extent this result was typical. The WBGT index appears to show that throughout the trial the canopies actually increased heat stress, but the interpretation of this finding is uncertain because many of the observations were made in conditions for which this index is unsuitable (Kerslake, 1972).

48. A more reliable estimate of heat stress and sweat loss could be obtained by calculating CET and P4SR for each of the 240 sets of observations made. This procedure, although extremely laborious, would be worthwhile. If the raft canopies do in fact increase heat stress and sweat loss, as the findings for WBGT would seem to show, they would hasten the onset of dehydration and reduce the raft occupants' prospects of survival. Such a finding would call for urgent corrective action. Even if on analysis the present rafts should be found to reduce heat stress, improvements might well be considered, as for example by increasing ventilation through the provision of roll-up side walls secured by pressure studs and 'velcro' closures. Calculation of heat stress indices corresponding to various degrees of increased ventilation (and of the increased radiant heat that would result from rolling up the walls) would provide a useful quantitative estimate of the likely benefits that might result.

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LEGENDS TO FIGURES

Fig. 1. : The 6 functions derived from the physiological observations for statistical analysis.

Fig. 2. : Physiological observations. Daily mean values for all subjects.

Fig. 3. : Daily mean values, for all subjects, of lying heart rate and oral temperature in relation to the wet-bulb globe temperature (WBG) of the environment in which they were measured.

Fig. 4. : Indoor environment in which each raft crew was medically examined on Day 3. GT, globe temperature; DB, dry-bulb temperature; WB, wet-bulb temperature; AV, air velocity (ft/min).

Fig. 5. : Daily mean values, for each raft, of the WBGT of the indoor environment in which medical examinations were made.

ANNEX E

1. Comments on meteorological observations by Regional Director (Mr. J.R.Bear), Bureau of Meteorology, Darwin.

"The weather conditions throughout the operation were rather varied, ranging from the true dry season conditions on the Sunday (more indicative of July, August conditions) to very humid pre wet conditions with local thunderstorm activity over the remainder of the period (indicative of October conditions).

Temperatures with the exception of the brief cool dry spell were generally a little above normal for September.

Observations inside the rafts indicated that conditions inside Raft B were generally warmer, more humid and less ventilated than the other rafts.

It is the lay opinion of all observers that either discipline or morale was lower in Raft B than other rafts, either caused by or causing the more uncomfortable conditions. This was borne out by the less friendly nature and co-operation by the test subjects in this raft and also possibly by the fact that for two nights running the canopy was deflated."

2. A study of the average figures shows little difference between the Rafts with the exception of the lower wind run on Raft B.

OPERATION SEASPRAY - METEOROLOGIC

SUMMARY

	RAFT A			RAFT B			RAFT C			RAFT D		
	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	
1. Dry Bulb °C	34.0	26.4	29.87	34.4	26.6	30.14	34.9	26.7	30.02	34.2	26.6	
2. Wet Bulb°C	28.0	22.2	25.3	29.0	22.1	25.7	28.1	20.6	25.4	27.6	20.9	
3. Dew Point	27	16	23.6	28	17	23.9	27	14	23.7	27	15	
4. Rel. Hum %	85	35	69.8	90	38	69.1	90	33	68.5	91	34	
5. Global Temp °C	37.5	26.5	30.4	37.2	26.7	30.7	37.3	26.7	30.6	37.2	26.1	
6. 2 Min. Wind Run	154	00	31	70	00	16.5	120	00	19	110	00	
7. Wind Speed m/sec	3.10	Calm	0.70	2.28	Calm	0.66	2.5	Calm	0.53	2.5	Calm	
8. WBGT	29.5	24.0	26.9	29.8	24.6	27.2	29.9	24.4	27	29.8	23.9	
9. V. Press. m.b.	38.1	18.8	30.4	38.6	19.1	30	38.9	16.4	29.3	34.8	16.6	
10. R.H. %	86	35	70.3	92	38	70.8	90	34	69.8	89	33	
11. Sea Temp °C												

PERATION SEASPRAY - METEOROLOGICAL OBSERVATIONS

S U M M A R Y

	RAFT C			RAFT D			VICINITY OF RAFTS			LAND BASE		
Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min	Mean
30.14	34.9	26.7	30.02	34.2	26.6	29.92	33.9	25.6	29.2	33.2	24.0	28.8
25.7	28.1	20.6	25.4	27.6	20.9	25.4	26.8	20.0	24.5	25.2	18.7	23.2
23.9	27	14	23.7	27	15	23.7	26	14	22.7	24	08	19.4
69.1	90	33	68.5	91	34	70.8	92	31	69.9	88	23	60.8
30.7	37.3	26.7	30.6	37.2	26.1	30.6	-	-	-	50.2	22.1	32.3
16.5	120	00	19	110	00	22.2	483	00	154	430	00	158
0.66	2.5	Calm	0.53	2.5	Calm	0.58	8.87	Calm	3.02	8.00	Calm	3.18
27.2	29.9	24.4	27	29.8	23.9	27.7	-	-	-	32.4	20.3	26.3
30	38.9	16.4	29.3	34.8	16.6	29.4	-	-	-	-	-	-
70.8	90	34	69.8	89	33	70						
							29.4	27.4	28.4			

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ANNEX F

FIELD LABORATORY RESULTS

1. The following records, and tests, were made at the field laboratory during 'Operation Seaspray'.

a. Urine. Volume, specific gravity, refractive index, qualitative tests for ketones, glucose and protein.

b. Faeces. Weight and moisture content

c. Food unconsumed.

d. Water unconsumed.

RESULTS

2. The results of qualitative tests for protein are summarised below in Table I. The results of qualitative tests for ketones in urine are shown in Table II. The amounts of food returned uneaten are shown in Table III, and unconsumed water in Table IV.

DISCUSSION AND RESULTS

3. The evaluation of these results involves some problems of method. Originally, the experiment was designed as a balanced statistical design suitable for the Analysis of Variance. However, one subject from Raft C and two from Raft D retired after a little more than 24 hours. This left three alternative methods for analysing the data.

4. The first was to analyse the data as though one subject from Raft D on the same ration (glucose) as the subject withdrawn had been physically in Raft C. The second method was to use all the results, from the four rafts except that 2 from Raft C and 1 from Raft D were omitted, so that there were a total of 51 subjects, 17 on each ration. The third would be to replace the missing data by a method used to minimise finance.

5. The disadvantages of the respective possibilities are: For the first, data from 9 subjects are discarded. This seems a pity, as these subjects had in fact contributed to the experiment and had been told that 'their results would be used'. Moreover, there is some slight objection to the practice of including the results of a subject from Raft D to Raft C. The second proposal above is valid, provided interacting of rafts with the other factors are not taken into account, and as it makes use of most of the data (only data from 3 subjects is omitted), is the procedure adopted in the analysis presented.

6. The Analysis of Variance for urine volume is shown in Table A.

TABLE A

Analysis of Variance - Urine Volumes

SOURCE OF VARIANCE	SUM OF SQUARES	DEGREE OF FREEDOM	MEAN SQUARES	VARIANCE RATIO AND SIGNIFICANCE
Days	2,467,188	3	822,396	1116 P<0.001
Rations	115,136	2	57,568	4.946 P<0.025
Days x Rations	6,032	4	1,508	0.2 NS
Rafts	99,792	3	33,264	2.858 P < 0.05

Individuals	523,703	45	11,638	1.5795 P<0.05
Residual	1,075,655	146	7,363	σ = 86.1
TOTAL	4,287,509	203		
(a) Subdivision of rafts				
Raft D vs A,B&C	80,514	1	80,514	6.918 ≃ 0.01
Within Rafts A,B&C	19,278	2	9,639	

It is plain from this analysis that, the volume of urine was less in Raft D, presumably this was due to the smaller number of subjects in this raft. The volumes of urine excreted increased in the order barley sugar, fudge, glucose. The volumes of urine decreased each day till the third day.

7. The analysis for urine refractive indices is shown in Table B.

TABLE B

Analysis of Variance Urine Refractive Index

SOURCE OF VARIANCE	SUM OF SQUARES x10 $^{-8}$	DEGREES OF FREEDOM	MEAN SQUARES x10^{-8}	VARIANCE RATIO AND SIGNIFICANCE
Days	13,522.92	3	4,507.64	61.85 P<0.001
Rations	248.41	2	124.2	Not significant
Days x Rations	56.33	4	14.08	Not significant
Rafts	262.24	3	87.41	Not significant
Individuals	9,474.29	46	205.96	2.8259 P<0.001
Residual	10,567.99	145	728827	σ = 0.0008
	34,132.18	203		
Subdivision				
Day 1 vs Days 2-4	13,505.92	1	13,505.92	
Between Days 2-4	17.00	2	8.5	NS

It is plain in this case that by the second day the ability to concentrate the urine had risen to its maximum and did not change thereafter. All other effects were non-significant.

8. In order to analyse the results obtained for the qualitative analyses (ketones and protein in urine), a 'scoring' system was used, giving 0 for negative, 1 for trace, 2 for small, or less than 30, and 3 for moderate, or more than 30. The analysis of variance of the results for proteins in urine on this basis is presented in Table C.

TABLE C

Analysis of Variance Protein in Urine

SOURCE OF VARIANCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	VARIANCE RATIO AND SIGNIFICANCE
Days	8.799	3	2.933	5.026
Rations	1.660	2	0.83	1.42 N.S.
Days x Rations	1.830	4	0.458	N.S.
Rafts	2.661	3	0.887	1.52 N.S.
Individuals	23.336	45	0.519	
Residual	88.121	146	0.604	
TOTAL	126.407	203		
Subdivision				
Day 1 vs Days 2-4	8.237	1	8.237	14.115
Between Days 2-4	0.562	2	0.281	N.S.

As the differences between individuals are not significant, greater than the residual variance, these two have been pooled to give a residual mean square of 0.5835 with 191 degrees of freedom for testing significance. It is clear that the only significant effect in proteinuria was an increase over all rations of the first day.

A similar study of ketonuria yields Table D.

TABLE D

Analysis of Variance - Ketones in Urine

SOURCE OF VARIANCE	SUM OF SQUARES	DEGREE OF FREEDOM	MEAN SQUARES	VARIANCE RATIO AND SIGNIFICANCE
Days	16.799	3	5.599	7.931
Rations	2.837	2	1.419	N.S.
Days x Rations	3.399	4	0.850	1.204 N.S.
Rafts	5.685	3	1.895	N.S.
Individuals	91.302	45	2.029	2.874 $P<0.001$
Residual	103.052	146	0.706	
TOTAL	223.074	203		
Subdivision				
Day 1 vs days 2-4	14.746	1	14.746	20.887 $P<0.001$
Days 2-4	2.052	2	1.026	1.453 N.S.

In this case, the only significant effect is that related to the changes from the first day to later days, eg an increase in ketonuria.

TABLE I

Qualitative Tests for Protein in Urine

DAY	RATION	RAFT A 15 Subjects	RAFT B 15 Subjects	RAFT C 15 Subjects	RAFT D 10 Subjects
3-4	None	3 Trace 1 +30	5 Trace 2 +30	10 Trace 1 +30	2 Trace
4-5	Glucose	3 Trace 1 <30 1 30+	3 Trace 1 +30	4 Trace	1 Trace
	Barley Sugar	2 Trace 3 <30	3 Trace 1 <30	4 Trace 1 30+	3 Trace
	Fudge	3 Trace 1 30+	2 Trace	5 Trace	3 Trace
5-6	Glucose	2 Trace 1 <30 1 30+	3 Trace 1 <30	3 Trace 1 <30	3 <30
	Barley Sugar	5 Trace	2 Trace 3 <30	3 Trace 2 <30	2 Trace 2 <30
	Fudge	5 Trace	5 Trace	3 Trace 2 <30	3 Trace
6-7	Glucose	1 Trace 1 30+	2 Trace 1 30+	4 Trace	3 Trace
	Barley Sugar	8 Trace	4 Trace 1 30+	4 Trace 1 30+	4 Trace
	Fudge	4 Trace	4 Trace 1 30+	4 Trace 1 30+	3 Trace

TABLE II

Qualitative Tests for Ketones in Urine

DAY	RATION	RAFT A 15 Subjects	RAFT B 15 Subjects	RAFT C 14 Subjects	RAFT D 10 Subjects
3-4	None	3 small	3 small	1 small	Nil
4-5	Glucose	1 moderate 1 small	2 small	1 small	1 small
	Barley Sugar	1 trace 1 small	1 trace 2 small	3 trace 1 small	3 small
	Fudge	3 small	Nil	2 small	2 small
5-6	Glucose	2 small 2 moderate-large	2 moderate	Nil	1 small 1 small-moderate
	Barley Sugar	1 small	1 small	1 trace 1 small-moderate	2 small
	Fudge	3 small 1 moderate	Nil	Nil	1 Trace
6-7	Glucose	1 small 2 moderate	1 small 1 moderate	2 small	1 moderate 1 small
	Barley Sugar	2 small	2 small	1 small 1 small-moderate 2 moderate	2 small 1 small-moderate
	Fudge	1 moderate	2 small	1 small	2 small

TABLE III

Uneaten Food (grams)

DAY	RATION	RAFT A 15 Subjects	RAFT B 15 Subjects	RAFT C 14 Subjects	RAFT D 10 Subjects
5	Glucose	218	60	0	79
	Barley Sugar	0	0	258	102
	Fudge	86	47	76	0
6	Glucose	218	141	172	230
	Barley Sugar	0	99	277	234
	Fudge	42	104	20	368
7	Glucose	246	97	267	127
	Barley Sugar	90	65	380	101
	Fudge	40	96	160	70

TABLE IV

Water Unconsumed (ml)

DAY	RAFT A 15 Subjects			RAFT B 15 Subjects			RAFT C 14 Subjects			RAFT D 10 Subjects		
	G	BS	F	G	BS	F	G	BS	F	G	BS	F
5	246	327	262	-	-	-	-	361	200	-	578	-
6	129	100	363	-	-	-	-	151	-	-	417	-
7	-	-	-	-	-	-	-	50	-	-	-	-