12. The Component Acids of some Wild Animal and Bird Fats

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Knowledge of the component fatty acids and glycerides of fats of land animals is at present restricted to comparatively few species, namely, the 'domestic' animals such as the ox, sheep, pig, horse and a few others; whilst amongst birds only fats of the domestic fowl, of a few sea-birds [Lovern, 1938] and, to a certain extent, of the goose have received detailed study. For the rest, analytical characteristics (saponification and iodine values etc.) have been recorded for fats from a number of wild animals, but there is a complete lack of data concerning the actual composition of depot or organ fats from the enormous range of land animal (including the human) species. This state of affairs stands in marked contrast to the very large number of seed and other fats from the vegetable kingdom which have now been comprehensively studied, and to the many excellent analyses which in recent years have been given of the component acids of fats from many aquatic animal and vegetable sources.

The present communication deals with the component fatty acids (and, in some instances, the component glycerides) present in a few wild animal and bird fats. It is fragmentary in that it merely records the details of various fats collected for the authors by the kindness of Dr R. Child (Director of the Coconut Research Scheme, Ceylon), Dr J. R. Vickery (of the Australian Commonwealth Department of Scientific and Industrial Research), and Dr A. J. E. Cave, Assistant Conservator of the Museum of the Royal College of Surgeons, London. The results are probably mainly valuable for the clear indications that systematic work on fats from a wide range of land animal species would lead to new discoveries of interrelationship between fat composition and biological species, together probably with fresh evidence as to the influences of diet, climate and life habit on the constitution of depot fats. With the exception of those of the kangaroo, which was shot when at large, and the giant panda, which was an inhabitant of the London Zoological Gardens, the other fats studied (lion, cat, sloth bear, sacred baboon, Somali sheep, emu and goose) were from animals and birds kept in captivity in the Zoological Gardens at Colombo.

It will be convenient to report separately upon each fat before proceeding to discuss the results obtained as a whole.

Experimental*

Lion fat

The animal (*Panthera leo* Pocock), from which the specimen of body fat was taken, had been in captivity at Colombo for several years, and had been fed chiefly on beef, supplemented latterly with liver. The fat was solid and was slightly contaminated with protein matter; it had sap. equiv. 293·0, I.V. 41·0, acid value 16·6, and contained 2·6 % of unsaponifiable matter. Analytical characteristics do not seem to have been recorded previously for lion fat, but Hooper [1912] quoted I.V. 57·7 for a tiger fat, and Rae [1924] I.V. 62·2 for a leopard fat. The more saturated character of the present specimen of lion fat may perhaps be connected with the long period spent in captivity by the animal.

* With the exception of the kangaroo fat, which was examined by Dr L. Maddison, the experimental work embodied in this communication was carried out by Mr I. C. Sime.—T. P. H.

The data obtained from the ester-fractionation analysis of the mixed fatty acids (95 g.) are summarized in Table 1.

Table 1. *Component acids of lion body fat*

Acid	'Solid' acids (50·6 %)	'Liquid' acids (49·4 %)	Total	Fatty acids % (wt.)	Fatty acids % (mol.)
Decanoic	—	1·3	1·3	1·4	2·1
Lauric	—	1·1	1·1	1·1	1·5
Myristic	2·8	1·9	4·7	4·9	5·7
Palmitic	23·8	4·4	28·2	28·9	30·3
Stearic	17·4	—	17·4	17·8	16·8
Arachidic	0·1	—	0·1	0·1	Trace
Tetradecenoic	—	0·6	0·6	0·6	0·8
Hexadecenoic	—	1·8	1·8	1·9	1·9
Oleic	6·5	32·7	39·2	40·3	38·3
Unsaturated C_{20-22}	—	3·0	3·0	3·0	2·6
Unsaponifiable	—	2·6	2·6	—	—

From the acids in appropriate ester-fractions *n*-decanoic acid (M.P. 31–32°), myristic, palmitic and stearic acids were identified, whilst oleic acid was identified after oxidation to 9:10-dihydroxystearic acid, M.P. 132°; no tetrahydroxystearic acids corresponding with octadecadienoic acid were definitely isolated, and the highest I.V. observed in the methyl ester-fractions of unsaturated C_{18} acids (83·1) also indicated the probable absence of polyethenoid C_{18} acids.

Cat fat

The body fat of a cat from the Colombo Zoological Gardens, stated to be a domestic animal the diet of which was not known, was a pale yellow solid at room temperature and, like the lion fat, was accompanied by a small proportion of protein. The purified fat had sap. equiv. 281·7, I.V. 43·6 and contained 0·6 % of unsaponifiable matter; its high acid value (64·4) indicated that considerable hydrolytic rancidity had occurred. Amthor & Zink [1897] recorded I.V. of 57·8 and 54·5 respectively for fats from European wild and domestic cats. Turner [1931] reported saturated fatty acids (methyl esters, sap. equiv. 226 and 253), which were liquid at room temperature, from the kidney tissue fat of the cat, but evidence of the presence of such acids in the body fat of the cat was not obtained by us.

Ester-fractionation etc., of the mixed fatty acids (63·7 g.) of the cat fat led to the fatty acid composition given in Table 2.

Table 2. *Component acids of cat body fat*

Acid	'Solid' acids (46·0 %)	'Liquid' acids. (54·0 %)	Total	Fatty acids % (wt.)	Fatty acids % (mol.)
Lauric	—	2·4	2·4	2·4	3·3
Myristic	2·3	1·3	3·6	3·6	4·2
Palmitic	24·4	4·6	29·0	29·2	30·5
Stearic	16·5	—	16·5	16·6	15·6
Tetradecenoic	—	1·2	1·2	1·2	1·4
Hexadecenoic	0·3	3·9	4·2	4·3	4·5
Oleic	2·5	38·0	40·5	40·8	38·7
Octadecadienoic	—	1·9	1·9	1·9	1·8
Unsaturated C_{20-22}	—	0·1	0·1	Trace	Trace
Unsaponifiable	Trace	0·6	0·6	—	—

The acids from the two lowest-boiling fractions of the methyl esters of the 'liquid' acids (respectively sap. equiv. 221·3, 256·3, I.V. 17·7, 44·4) were oxidized at 0° with dilute alkaline permanganate solution and the saturated acids separated, by crystallization from light petroleum, from dihydroxy-acids produced by the oxidation. The saturated acids were all solid at room temperature and melted at 47° (acids from fraction L1) and 54–55° (acids from fraction L2); they accorded respectively with mixtures of about 30 % lauric

with 70% myristic, and of about 30% myristic with 70% palmitic acid. The liquid saturated acids observed by Turner [1931] in the kidney tissue fat of the cat are therefore not present in its depot fats.

The major components, palmitic, stearic and oleic acid were also identified, the last named by conversion into the 9:10-dihydroxystearic acid, M.P. 129–130°.

Kangaroo fat

The body fat sent to us by Dr J. R. Vickery was collected from a kangaroo shot by Dr J. H. Riches of the National Field Station, Cunnamulla, Queensland, and identified by the Australian Museum, Sydney, as a young adult Great Grey Kangaroo (*Macropus major*). Owing to prevailing drought the animal was not rich in fat. The fat was a soft white solid at room temperature, sap. equiv. 285·0, I.V. 50·1, unsaponifiable 0·2%, acid value 3·4.

In spite of the small quantity available, the fat (144·4 g.) was resolved into two fractions by systematic crystallization from acetone at −10°, and the component acids of each fraction determined, in order to obtain an approximate idea of the component glycerides present.

Table 3 summarizes the component acid data for the two fractions of the fat.

Table 3. *Component acids of fractions A and B of kangaroo body fat*

Acid	'Solid' acids	'Liquid' acids	Total	Fatty acids % (wt.)	Fatty acids % (mol.)
Fraction A (insoluble in acetone at −10°, 48·3 g., I.V. 29·9)					
Myristic	4·8	2·0	6·8	6·8	8·0
Palmitic	27·7	4·9	32·6	32·6	34·3
Stearic	23·9	—	23·9	23·9	22·7
Arachidic	2·5	—	2·5	2·5	2·1
Tetradecenoic	—	0·2	0·2	0·2	0·3
Hexadecenoic	—	1·2	1·2	1·2	1·3
Oleic	6·7	24·9	31·6	31·7	30·3
Octadecadienoic	—	0·3	0·3	0·3	0·3
Unsaturated C_{20-22}	—	0·8	0·8	0·8	0·7
Unsaponifiable	0·1	—	0·1	—	—
Fraction B (soluble in acetone at −10°, 96·1 g., I.V. 59·4)					
Lauric	—	0·3	0·3	0·3	0·4
Myristic	0·7	2·9	3·6	3·6	4·4
Palmitic	16·2	5·7	21·9	21·9	23·4
Stearic	9·1	—	9·1	9·1	8·8
Arachidic	1·0	—	1·0	1·0	0·9
Tetradecenoic	—	0·5	0·5	0·5	0·6
Hexadecenoic	—	3·4	3·4	3·4	3·7
Oleic	4·3	48·3	52·6	52·6	50·9
Octadecadienoic	—	3·8	3·8	3·8	3·7
Unsaturated C_{20-22}	—	3·7	3·7	3·8	3·2
Unsaponifiable	0·1	—	0·1	—	—

(Owing to enemy action, the acids from the residual fractions of the esters of both 'liquid' acids were lost before their possible content of unsaponifiable matter had been determined, and it was therefore not possible to distinguish between unsaponifiable matter and the presence of unsaturated C_{20-22} acids; the data are expressed, in accordance with the small proportions of unsaponifiable matter known to be present, in terms of assumed unsaturated C_{20} and C_{22} acids.)

From the component acids in fractions A and B of the kangaroo fat those of the whole fat may be calculated, whilst a general idea of the component glycerides can also be obtained by the assumption (which will not be quite accurate) that di-'oleo'-glycerides are absent from fraction A, and tri-unsaturated glycerides from fraction B (Table 4).

The kangaroo fat thus consists largely of a mixture of 'oleo'-palmitostearin and palmitodi-'olein', with some 'oleo'-dipalmitin and minor amounts of stearodi-'olein' and palmitostearins (and possibly a little tri-'olein').

Table 4. *Component acids and possible component glycerides of kangaroo body fat*

	Fraction A	Fraction B	Whole fat	
Wt. of fraction (g.)	48·3	96·1	144·4	
I.V.	29·9	59·4	50·1	
Sap. equiv.	282·4	286·2	285·0	
Glycerides % (wt.)	33·5	66·5		
Glycerides % (mol.)	33·8	66·2		
Component acids (increments):	% (mol.)	% (mol.)	% (wt.)	% (mol.)
Lauric	—	0·2	0·2	0·2
Myristic	2·7	2·9	4·7	5·6
Palmitic	11·6	15·5	25·5	27·1
Stearic	7·7	5·8	14·1	13·5
Arachidic	0·7	0·6	1·5	1·3
Tetradecenoic	0·1	0·4	0·4	0·5
Hexadecenoic	0·4	2·5	2·7	2·9
Oleic	10·3	33·7	45·5	44·0
Octadecadienoic	0·1	2·4	2·6	2·5
Unsaturated C_{20-22}	0·2	2·2	2·8	2·4
Groups of component acids (increments):				
Palmitic ($+C_{14}$, C_{12})	14·3	18·6	—	32·9
Stearic ($+C_{20}$)	8·4	6·4	—	14·8
Unsaturated ($C_{16}+C_{14}$)	0·5	2·9	—	3·4
„ ($C_{18}+C_{20}$, C_{22})	10·6	38·3	—	48·9
Probable component glycerides (approx.)				
Fully saturated (0·5 %):				
Palmitostearins	0·5	—	—	0·5
Mono-'oleo'-disaturated (50·8 %):				
Hexadecenopalmitostearin	1·6	—	—	1·6
'Oleo'-dipalmitin	8·9	—	—	8·9
'Oleo'-palmitostearin	22·9	17·4	—	40·3
Di-'oleo'-monosaturated (48·7 %):				
Palmitodi-'olein'	—	47·0	—	47·0
Stearodi-'olein'	—	1·7	—	1·7

Somali sheep fat

The Somali or 'fat-tailed' sheep, found chiefly in Asia Minor and Persia, is peculiar in that its tail serves as an additional fat depot. The fat now studied, however, was from the rump of an animal of this species which had been in the Colombo Zoo for about 7 years, during which period it had been fed chiefly on greenstuff with concentrates (probably mainly coconut cake). The fat was a soft white solid with a consistency resembling that of lard rather than ordinary sheep tallow. It had sap. equiv. 289·1 I.V. 49·0, unsaponifiable matter 0·5 %, and was somewhat rancid when received (acid value 52·0).

The determination of component fatty acids of the Somali sheep-rump fat (75 g.) gave the results shown in Table 5.

Table 5. *Component acids of Somali sheep rump fat*

Acid	'Solid' acids (35·0 %)	'Liquid' acids (65·0 %)	Total	Fatty acids % (wt.)	Fatty acids % (mol.)
Myristic	0·5	1·7	2·2	2·2	2·7
Palmitic	17·3	5·6	22·9	23·0	24·6
Stearic	14·8	—	14·8	14·9	14·3
Tetradecenoic	—	0·3	0·3	0·3	0·4
Hexadecenoic	—	2·5	2·5	2·5	2·7
Oleic	2·4	53·0	55·4	55·7	54·0
Octadecadienoic	—	0·8	0·8	0·8	0·7
Unsaturated C_{20-22}	—	0·6	0·6	0·6	0·6
Unsaponifiable	Trace	0·5	0·5	—	—

From appropriate ester-fractions, myristic, palmitic and stearic acids were formally identified, and 9:10-dihydroxystearic acid, M.P. 129·5° and 9:10-dihydroxypalmitic

acid, M.P. 123·5°, were also isolated by alkaline permanganate oxidation of acids from fractions rich in oleic and hexadecenoic esters respectively. No crystalline tetrahydroxystearic acids were obtained.

Ceylon or sloth bear fat

A comparatively large specimen (*ca.* 600 g.) of the body fat of a young Ceylon or sloth bear (*Melursus ursinus* Shaw) was submitted from Colombo; the animal had not been long in captivity, during which it had been fed on rice and sugar with occasional meat. The natural diet of the sloth bear is mainly herbivorous (largely fruits), supplemented by honey and sometimes insects (especially white ants) and young birds and eggs.

The fat, which was almost free from rancidity (acid value 1·8), was almost colourless and odourless and barely solid at room temperature. It had sap. equiv. 282·4, I.V. 60·3, and contained 0·8 % of unsaponifiable matter.

The amount of material available permitted determination of the component acids in the whole fat (Table 6) and also resolution of a larger portion into several fractions, from the component acids in each of which information as to the component glycerides of the bear fat was obtained (Table 7).

Table 6. *Component acids of Ceylon bear body fat*

Acid	'Solid' acids (31·0 %)	'Liquid' acids (69·0 %)	Total	Fatty acids % (wt.)	Fatty acids % (mol.)
Myristic	1·5	1·0	2·5	2·6	3·0
Palmitic	25·2	3·3	28·5	28·7	30·2
Stearic	3·4	—	3·4	3·4	3·3
Tetradecenoic	—	1·4	1·4	1·4	1·6
Hexadecenoic	—	10·5	10·5	10·6	11·2
Oleic	0·9	49·2	50·1	50·5	48·2
Octadecadienoic	—	1·0	1·0	1·0	1·0
Unsaturated C_{20-22}	—	1·8	1·8	1·8	1·5
Unsaponifiable	Trace	0·8	0·8	—	—

Palmitic acid (M.P. 62°) was identified in the acids of some of the ester-fractions of the 'solid' group; appropriate ester-fractions of the unsaturated group yielded acids which, on oxidation with alkaline permanganate, gave respectively 9:10-dihydroxypalmitic acid, M.P. 124°, and 9:10-dihydroxystearic acid, M.P. 129·5°, thus confirming the presence of hexadecenoic and oleic acids. No tetrahydroxystearic acids were obtained, nor did the unsaturated C_{18} acids from ester-fractions consisting wholly of these yield any crystalline bromo-derivatives.

Systematic crystallization of the bear fat (369 g.) from acetone at varying concentrations and temperatures (from 0 to −30°) resolved it into five fractions, the component acids in each of which were determined by lead salt-alcohol separation and ester-fractionation. From the resulting data the probable main component glycerides of the fat can be approximately suggested (Table 7).

The chief components are di-unsaturated glycerides and, owing to the presence of nearly 14 % of hexadecenoic (and lower unsaturated) acids, over 20 % of palmito-hexadeceno-'oleins' accompanies palmitodi-'olein', which forms about 45 % of the bear fat. The tri-unsaturated glycerides present are also probably wholly mixed hexadeceno-'oleins'.

Few previous data exist for bear fats. Hoyt [1934] studied the back and hind quarter fats of the American black bear (*Ursus americanus*) and found that the back fat contained about 16 % saturated and 84 % unsaturated (I.V. 98·8) acids, whilst the hindquarter fat component acids were made up of about 33 % saturated and about 67 % unsaturated (I.V. 82·8) acids. For some other bear fats iodine values have been recorded as follows: Ceylon bear, 56·7, 60·7 [Rae, 1922]; Himalayan bear (*U. torquatus* Wagner), 52·7, 62·8 [Hooper, 1908]; brown bear (*U. arctos*), pancreatic 98·5, perinephric 107·4 [Raikow, 1904], femoral 80·7 [Schneider & Blumenfeld, 1906].

Table 7. *Probable component glycerides (% mol.) present in Ceylon bear fat*

Fraction...	A	B	C	D	E	Whole fat
Wt. of fraction (g.)	12·9	59·3	201·8	37·5	57·5	369·0
I.V.	12·7	39·8	59·6	76·6	83·7	
Sap. equiv.	274·5	280·4	282·3	286·5	279·0	
Glycerides % (wt.)	3·5	16·1	54·7	10·2	15·5	
Glycerides % (mol.)	3·6	16·2	54·5	10·0	15·7	
Component acids (increments):						
Lauric	—	—	—	—	0·5	0·5
Myristic	0·6	0·5	2·3	0·5	0·5	4·4
Palmitic	1·7	7·3	16·5	1·4	1·1	28·0
Stearic	0·7	1·3	0·4	—	—	2·4
Dodecenoic	—	—	—	—	0·4	0·4
Tetradecenoic	—	0·2	0·4	0·3	0·7	1·6
Hexadecenoic	—	0·7	5·6	1·5	4·0	11·8
Oleic	0·6	6·0	28·7	6·1	7·7	49·1
Octadecadienoic	—	0·2	0·6	Trace	0·3	1·1
Unsaturated C_{20-22}	—	—	Trace	0·2	0·5	0·7
Groups of component acids (increments):						
Palmitic ($+C_{14}$, C_{12})	2·3	7·8	18·8	1·9	2·1	32·9
Stearic	0·7	1·3	0·4	—	—	2·4
Hexadecenoic ($+C_{14}$, C_{12})	—	0·9	6·0	1·8	5·1	13·8
'Oleic' ($+C_{20-22}$)	0·6	6·2	29·3	6·3	8·5	50·9
Probable component glycerides (approx.)						
Fully saturated (1·8 %):						
Dipalmitostearin	1·8	—	—	—	—	1·8
Mono-'oleo'-disaturated (16·2 %):						
'Oleo'-dipalmitin	1·6	7·4	1·8	—	—	10·8
'Oleo'-palmitostearin	0·2	4·0	1·2	—	—	5·4
Di-unsaturated-mono-saturated (68·2 %):						
Palmito-hexadeceno-'olein'	—	2·6	18·1	Nil–1·1	Nil–5·8	20·7–27·6
Palmitodi-'olein'	—	2·2	33·4	5·7–4·6	6·2–0·4	47·5–40·6
Tri-unsaturated (13·8 %):						
Dihexadeceno-mono-'olein'	—	—	—	1·1–nil	5·8–nil	6·9–nil
Hexadecenodi-'olein'	—	—	—	3·2–4·3	3·7–9·5	6·9–13·8

Giant panda fat

A specimen of fatty tissue from between the anterior abdominal wall musculature and the peritoneum of a giant panda (*Ailuropoda melanoleuca*) which had died in the Zoological Gardens, London, was kindly supplied to us by Dr A. J. E. Cave, who dissected it. This animal lives at high altitudes (10,000–14,000 ft.) in the mountains of south-west China and is believed to feed exclusively on bamboo, the debris of which has been observed by Dr Cave in food pockets between the teeth of fresh skulls. The panda is remarkable as an ancestrally carnivorous animal which has become purely herbivorous, and is classed as a Procyonid.

The abdominal fatty tissue (182 g.) gave on extraction with acetone 4·1 % of non-fatty tissue and 92·6 % of a white fat, barely solid at room temperature, which had sap. equiv. 283·4, I.V. 64·8, acid value 3·0, and contained only traces (0·1 %) of unsaponifiable matter. Its component acids, as determined by ester-fractionation, are given in Table 8.

The major component acids are oleic, palmitic and octadecadienoic acids; these, and also myristic acid, were definitely isolated and identified. The unsaturated C_{18} acids were studied in the case of ester fractions whose I.V. (103·7) indicated a mixture of about 80 % oleic and 20 % octadecadienoic acids. The mixed acids (4·3 g.), oxidized at 0° with dilute alkaline permanganate, yielded 1·5 g. 9:10-dihydroxystearic acid, M.P. 131°, and 0·4 g. of tetrahydroxystearic acid, M.P. 155°; another portion (3·6 g.) furnished 0·5 g. of tetrabromostearic acid, M.P. 115°, on addition of bromine to a light petroleum solution. The diethenoid acid present, therefore, gave about 40 % of the theoretical yields both of tetrahydroxystearic acid, M.P. 155°, and of the tetrabromostearic acid, M.P. 115°, indicating

Table 8. *Component fatty acids of giant panda abdominal fat*

Acid	'Solid' acids (34·8 %)	'Liquid' acids (65·2 %)	Total	Fatty acids % (wt.)	Fatty acids % (mol.)
Lauric	0·1	0·3	0·4	0·4	0·6
Myristic	3·4	1·6	5·0	5·0	5·8
Palmitic	24·1	2·3	26·4	26·4	27·8
Stearic	6·7	—	6·7	6·7	6·4
Tetradecenoic	—	0·8	0·8	0·9	1·0
Hexadecenoic	—	3·6	3·6	3·6	3·9
Oleic	0·5	44·6	45·1	45·1	43·1
Octadecadienoic	—	11·9	11·9	11·9	11·4
Unsaponifiable	Trace	0·1	0·1	—	—

that it consisted very largely of 'seed fat' linoleic acid. It is accordingly probable [cf. Hilditch *et al.* 1939] that the unusually high content (for an animal depot fat) of octadecadienoic acid represents linoleic acid assimilated from the herbivorous diet of the panda.

Sacred baboon fat

A specimen of abdominal fat from the body of a sacred (or dog-faced) baboon (*Papio hamadryas*) which had lived many years in the Colombo Zoological Gardens was examined. In the wild state this species feeds chiefly on insects, small animals, fruit, berries and roots of edible grasses; the diet of the animal during captivity was, so far as is known, chiefly boiled rice and fruit.

The fat was a pale greenish-yellow coloured liquid at room temperature, with sap. equiv. 286·5, I.V. 77·0, acid value 8·4, and unsaponifiable matter 0·1 %. The component fatty acids were determined directly on one portion of the fat (68 g.), whilst another (39 g.) was first resolved into two fractions by crystallization from acetone (195 c.c.) at −10°.

The results of lead salt-alcohol separation and ester-fractionation of the mixed acids from the whole fat are summarized in Table 9.

Table 9. *Component acids of sacred baboon abdominal fat*

Acid	'Solid' acids (26·0 %)	'Liquid' acids (74·0 %)	Total	Fatty acids % (wt.)	Fatty acids % (mol.)
Myristic	1·6	1·6	3·2	3·2	3·9
Palmitic	16·6	2·3	18·9	18·9	20·2
Stearic	5·8	—	5·8	5·8	5·6
Tetradecenoic	—	0·8	0·8	0·8	1·0
Hexadecenoic	—	3·8	3·8	3·8	4·1
Oleic	2·0	51·8	53·8	53·8	52·1
Octadecadienoic	—	13·1	13·1	13·2	12·7
Unsaturated C_{20-22}	—	0·5	0·5	0·5	0·4
Unsaponifiable	Trace	0·1	0·1	—	—

Palmitic and stearic acids were isolated and identified from appropriate ester-fractions. The acids from ester-fractions (I.V. 103·3) which consisted wholly of a mixture of about 80 % oleic and 20 % octadecadienoic acids gave, on addition of bromine to a light petroleum solution, a yield of about 25 % of theory of the tetrabromostearic acid, M.P. 114·5°; whilst alkaline permanganate oxidation at 0° furnished only very small yields of tetrahydroxystearic acid, M.P. 155° (with larger amounts of the 9:10-dihydroxystearic acid, M.P. 129°). The linoleic acid of seed fats was thus present in some quantity, probably derived from the diet.

The proportion of palmitic acid was unexpectedly low and the small quantity of fat which remained was submitted to analysis after separation into two portions by crystallization from acetone, partly in order to check this result, and also to afford a rough indication of the component glycerides present. The results are briefly summed up in Table 10.

Table 10. *Component acids (% mol.) of sacred baboon fat fractions from acetone*

Fraction	A	B	Whole fat	Fraction	A	B	Whole fat
Wt. of fraction (g.)	13·6	25·1	38·7	Component acids (increments):			
I.V.	66·4	84·1		Myristic	2·0	0·7	2·7
Sap. equiv.	286·5	286·9		Palmitic	6·0	12·5	18·4
Glycerides % (wt.)	35·1	64·9		Stearic	6·2	1·4	7·6
Glycerides % (mol.)	35·2	64·8		Tetradecenoic	0·4	0·8	1·2
				Hexadecenoic	2·4	4·3	6·8
				Oleic	15·3	34·8	50·1
				Octadecadienoic	2·4	10·1	12·5
				Unsaturated C_{20-22}	0·5	0·2	0·7

This further analysis confirms that the palmitic acid content of the baboon fat does not exceed 20 %, and suggests that the chief component glycerides are palmitodi-'oleins', (*ca.* 40 %), stearodi-'oleins' (15 %) and some palmito-hexadeceno-'oleins' (*ca.* 15 %), with some 20 % of triunsaturated glycerides, probably mainly linoleodiolein with some hexadecenodi-'oleins'; a little 'oleo'-palmitostearin and very small proportions of palmitostearins may also be present.

Emu fat

The subcutaneous tissue fat of an Australian emu (*Dromalus novae-hollandiae* Lath.) which had lived for many years in the Colombo Zoological Gardens was submitted for study. The natural diet of the bird is fruit, roots and herbage; in captivity it had been fed on various grains and concentrates. The fat was a white solid at room temperature, sap. equiv. 288·2, I.V. 65·8, unsaponifiable matter 0·3 %.

The component acids were determined on the mixed fatty acids from 100 g. of the emu fat (Table 11).

Table 11. *Component fatty acids of emu subcutaneous fat*

Acid	'Solid' acids (29·3 %)	'Liquid' acids (70·7 %)	Total	Fatty acids % (wt.)	Fatty acids % (mol.)
Myristic	—	0·9	0·9	0·9	1·1
Palmitic	15·8	1·7	17·5	17·5	18·8
Stearic	10·1	—	10·1	10·1	9·9
Arachidic	0·6	—	0·6	0·6	0·5
Tetradecenoic	—	0·9	0·9	0·9	1·1
Hexadecenoic	—	2·1	2·1	2·1	2·3
Oleic	2·6	59·3	61·9	62·2	60·8
Octadecadienoic	—	5·2	5·2	5·2	5·1
Unsaturated C_{20-22}	—	0·5	0·5	0·5	0·4
Unsaponifiable	0·2	0·1	0·3	—	—

Palmitic, stearic and arachidic acids were definitely identified in specific fractions of the esters of the saturated group of acids, whilst the acids from an ester-fraction containing only unsaturated C_{18} acids yielded on oxidation with cold alkaline permanganate solution the 9:10-dihydroxystearic acid, M.P. 129°, but no crystalline tetrahydroxystearic acid was detected.

Morrison [1926] has recorded the following partial analysis for an emu perinephric fat: 40 % of acids (palmitic and stearic) from ether-insoluble lead salts, and 60 % of acids from ether-soluble lead salts, with I.V. 124·5 and yielding ether-insoluble bromo-additive compounds corresponding to 11 % of linolenic acid.

Grey-goose fat

The grey lag goose (*Anser anser*) is considered to be the immediate ancestor of the domestic goose. The fat (from the abdominal cavity) examined was from a bird reared in captivity at Colombo, whose diet probably included coconuts as such and in the form of coconut oil cake. It was solid at room temperature, and had developed hydrolytic

rancidity (acid value 41·2). It had sap. equiv. 269·7, I.V. 57·1 and contained 0·2 % of unsaponifiable matter.

The results of ester-fractionation determination of the fatty acids from the grey-goose fat (60 g.) are summarized in Table 12.

Table 12. *Component fatty acids of grey-goose abdominal fat*

Acid	'Solid' acids (25·0 %)	'Liquid' acids (75·0 %)	Total	Fatty acids % (wt.)	Fatty acids % (mol.)
Lauric	—	12·2	12·2	12·3	15·8
Myristic	4·4	3·8	8·2	8·2	9·3
Palmitic	14·4	5·9	20·3	20·3	20·5
Stearic	5·6	—	5·6	5·6	5·1
Tetradecenoic	—	0·6	0·6	0·6	0·7
Hexadecenoic	—	2·5	2·5	2·5	2·5
Oleic	0·4	41·1	41·5	41·6	38·1
Octadecadienoic	—	6·6	6·6	6·6	6·1
Unsaturated C_{20-22}	—	2·3	2·3	2·3	1·9
Unsaponifiable	0·2	Trace	0·2	—	—

Myristic, palmitic and stearic acids were identified in appropriate fractions of the methyl esters of the 'solid' acids, and an ester-fraction containing only unsaturated C_{18} acids gave, on oxidation with dilute alkaline permanganate at 0°, 9:10-dihydroxystearic acid, M.P. 129°, but no crystalline tetrahydroxystearic acids. From the two lowest-boiling fractions of the esters of the 'liquid' acids (sap. equiv. 215·8, 216·3, I.V. 1·5, 1·5 respectively), lauric acid was isolated and identified by M.P. and mixed M.P.

From the equivalents and iodine values of the 'solid' and 'liquid' fatty acids obtained by lead salt-ether separation, or of those of the saturated fatty acids isolated by the Bertram [1925] oxidation process, from domestic goose fat, Grossfeld [1930; 1931] suggested a fatty acid composition of palmitic 21, stearic 11, oleic 49 and linoleic 19 %; but pointed out that the palmitic acid content, calculated from the equivalent of the total mixed fatty acids, was much higher than that calculated from that of the separated 'solid' acids, and attributed the discrepancy to the presence of fatty acids of lower mol. wt. than palmitic acid (*v. infra*, p. 109).

Discussion

I. *The animal fats*

The weight and molar percentages of the component acids of the seven animal fats described in the previous pages may be compared (Table 13).

The palmitic acid content of these fats may first be considered. With the exception of the fats of the baboon and the Somali sheep, the molar percentage of palmitic acid in all cases falls within the limits of 30 ± 3 % which Hilditch & Longenecker [1937] concluded to be characteristic for nearly all tallows (ox and sheep depot fats) and other workers have also observed in the body fats of the pig and several other herbivorous mammals [cf. Hilditch, 1940]. The somewhat lower proportion of palmitic acid in the Somali sheep fat is fully in accordance with recent observations on the domestic sheep [Hilditch & Pedelty, 1941], which show the palmitic acid content of sheep body fats to lie usually within the limits of 24·5–28·5 % (mol.). The only real exception in the present series is that of the baboon fat, in which palmitic acid forms only about 20 % (mol.) of the fatty acids.

The most striking feature of the present observations, however, is the very close resemblance of the fatty acids (including both major and minor components) of the lion, cat, kangaroo and Somali sheep fats to those of other 'stearic-rich' depot fats in the ox, sheep and pig groups of domestic herbivorous animals. This is not unnatural in the case of the Somali sheep, but it is perhaps remarkable that wholly carnivorous animals like

Table 13. *Component acids of depot fats of seven wild animals*

	Lion	Cat	Kangaroo	Somali sheep	Ceylon bear	Giant panda	Sacred baboon
			Weight percentages				
Decanoic	1·4	—	—	—	—	—	—
Lauric	1·1	2·4	0·2	—	—	0·4	—
Myristic	4·9	3·6	4·7	2·2	2·6	5·0	3·2
Palmitic	28·9	29·2	25·5	23·0	28·7	26·4	18·9
Stearic	17·8	16·6	14·1	14·9	3·4	6·7	5·8
Arachidic	0·1	—	1·5	—	—	—	—
Tetradecenoic	0·6	1·2	0·4	0·3	1·4	0·9	0·8
Hexadecenoic	1·9	4·3	2·7	2·5	10·6	3·6	3·8
Oleic	40·3	40·8	45·5	55·7	50·5	45·1	53·8
Octadecadienoic	—	1·9	2·6	0·8	1·0	11·9	13·2
Unsaturated C_{20-22}	3·0	Trace	2·8	0·6	1·8	—	0·5
			Molar percentages				
Decanoic	2·1	—	—	—	—	—	—
Lauric	1·5	3·3	0·2	—	—	0·6	—
Myristic	5·7	4·2	5·6	2·7	3·0	5·8	3·9
Palmitic	30·3	30·5	27·1	24·6	30·2	27·8	20·2
Stearic	16·8	15·6	13·5	14·3	3·3	6·4	5·6
Arachidic	Trace	—	1·3	—	—	—	—
Tetradecenoic	0·8	1·4	0·5	0·4	1·6	1·0	1·0
Hexadecenoic	1·9	4·5	2·9	2·7	11·2	3·9	4·1
Oleic	38·3	38·7	44·0	54·0	48·2	43·1	52·1
Octadecadienoic	—	1·8	2·5	0·7	1·0	11·4	12·7
Unsaturated C_{20-22}	2·6	Trace	2·4	0·6	1·5	—	0·4

the lion and cat whose diet is largely protein, and a marsupial so widely removed from our domestic mammalia in the evolutionary system, should elaborate fat reserves almost indistinguishable in composition from those of the common herbivorous farm animals.

All the fats (except that of the panda) were found to contain traces of unsaturated acids of the C_{20} and C_{22} groups, those of the lion and kangaroo containing over 2% of these constituents. In this respect the present group of fats is exactly similar to those of the ox, sheep, pig, rat etc. The presence of only traces of these acids in the cat fat suggests incidentally that fish had not formed any appreciable proportion of the diet of the animal concerned.

The presence of small proportions of lauric acid in the lion and cat fats (and of decanoic acid in the lion fat) is somewhat curious. Conceivably, these acids might be derived, indirectly or, so to speak, at second hand, from acids assimilated from coconut cake by the animals whose flesh was eaten by the lion and cat at Colombo, but on the other hand lauric acid was not observed in the fats of the Somali sheep and emu, which are known to have received concentrates of which coconut cake would be a constituent.

In contrast to the resemblances mentioned to farm animal depot fats, the fats from three of the animals studied—the Ceylon bear, giant panda and sacred baboon—show marked dissimilarities from the more usual type of animal body fat. Of these three fats (all of which are relatively poor in stearic acid) the bear fat is noteworthy for its unusually high content of hexadecenoic acid, which incidentally was shown, by the more detailed examination made, to be present in about one-third of the molecules of triglycerides of the fat. The diet of the animal apparently differed little from that of the baboon (the fatty acids of which contained only the usual minor proportions of hexadecenoic acid), and some other cause than food must apparently be considered. It is evident that detailed study of fats from a wider range of bear species would be interesting.

The fats of the giant panda and the sacred baboon contained unusually large proportions of octadecadienoic acid, which proved to be the characteristic vegetable or seed fat linoleic acid and not the ill-defined isomerides which are found in the ox or sheep depot fats and milk fats. This suggests the possibility in these instances of assimilation of linoleic

glycerides from the vegetables food supplied but, again, the bear (fed on a similar diet to that of the baboon) laid down only very minor quantities of octadecadienoic glycerides. The linoleic acid content of the panda fat is the only feature which places it apart from the usual type of low-stearic animal body fat, but the sacred baboon fat is characterized not only by similar high linoleic acid content, but by its comparatively low proportions of palmitic acid. Here again is an indication that detailed study of fats of the Primates (including man), which has been wholly neglected up to the present, may yield results of considerable interest.

Fragmentary as the data in this communication admittedly are, it is at least clear that no general correlation can be made between the composition of the body fats of the animals, either with diet, or with other factors such as climate etc. We meet, on the one hand, animals of extremely divergent species and origin, feeding on widely differing diets, with body fats of closely similar composition; and, on the other hand, we have encountered definite peculiarities in one or more component acids of the body fats of other animals, the herbivorous diets of which were on the whole very similar. In the latter instances it would appear that biological differences may have a definite influence, but the accumulation of many more data is obviously requisite before any clear view can be formulated.

II. *Emu and grey-goose fats*

The weight and molar percentages of the component acids in these two bird fats are quoted in Table 14, together with (for comparison) those of the abdominal fat of a 2 years' old domestic fowl (Light Sussex hen) previously analysed by Hilditch *et al.* [1934].

Table 14. *Component acids of emu, grey-goose and hen body fats*

	Weight percentages			Molar percentages		
	Emu (sub-cutaneous)	Grey-goose (abdominal)	Light Sussex hen (abdominal)	Emu (sub-cutaneous)	Grey-goose (abdominal)	Light Sussex hen (abdominal)
Lauric	—	12·3	—	—	15·8	—
Myristic	0·9	8·2	1·2	1·1	9·3	1·5
Palmitic	17·5	20·3	24·0	18·8	20·5	25·5
Stearic	10·1	5·6	4·1	9·9	5·1	3·9
Arachidic	0·6	—	—	0·5	—	—
Tetradecenoic	0·9	0·6	—	1·1	0·7	—
Hexadecenoic	2·1	2·5	6·7	2·3	2·5	7·2
Oleic	62·2	41·6	42·5	60·8	38·1	41·0
Octadecadienoic	5·2	6·6	20·8	5·1	6·1	20·3
Unsaturated C_{20-22}	0·5	2·3	0·7	0·4	1·9	0·6

The palmitic acid content of bird fats (including sea-birds [Lovern, 1938]) appears, in the few instances available, to be generally lower than that of land animals, and is frequently not more than 20 % (mol.) of the total fatty acids.

The emu fat, although only containing 19 % of palmitic acid, had about 10 % of stearic acid in its component acids, whilst the main component was oleic acid (61 % mol.). In its minor proportions of octadecadienoic and hexadecenoic acids, with traces of myristic, arachidic, tetradecenoic and unsaturated C_{20-22} acids, as well as in its content of palmitic and stearic acids, it shows considerable general resemblance to depot fats of the larger land animals. It differs from these in a very high content of oleic acid and in the definitely lower proportion of palmitic acid.

The fatty acids of the grey goose have resemblance in their unsaturated components to the corresponding acids of land animal depot fats, but differ in respect of the saturated acids; here there are notable proportions of lauric acid and the myristic acid content is also somewhat high. It is possible, but not certain, that some of the lauric and myristic glycerides are the result of assimilation of coconut cake.

As already mentioned, Grossfeld [1930; 1931] was able to suggest, by partial analysis of goose and hen body fatty acids, that fatty acids of lower molecular weight than palmitic acid were present. In the case of hen body fats, Hilditch *et al.* [1934] showed that Grossfeld's results were to be explained not by the presence of saturated acids of lower molecular weight than palmitic but by that of an unsaturated acid (hexadecenoic) of lower molecular weight than oleic acid; and that the component acids of hen body fats included about 7 % (mol.) of hexadecenoic acid. To conclude that this was characteristic for all bird fats is shown to be incorrect by the present studies of grey goose and emu fats, whose component acids both contain only 2–3 % (mol.) of hexadecenoic acid. The figures for the grey-goose fat support, in fact, Grossfeld's original suggestion, for 25 % (mol.) of the component acids are made up of lauric and myristic acids.

It is hoped in due course to return to this matter and to undertake studies by the modern technique of the body fats of the domestic goose and other domestic and wild birds.

Summary

The component acids of the body fats of seven animals and two birds not hitherto studied have been examined in detail.

Four of the fats—those of the lion, cat, kangaroo and Somali sheep—closely resembled in quantitative composition the 'stearic-rich' depot fats of domestic herbivorous mammals, in spite of great differences in the various species (carnivorous feline, herbivorous marsupial and herbivorous ovine).

The three remaining animal fats—from the Ceylon bear, giant panda and sacred baboon—differed materially in one respect or another from the more usual depot fatty acid composition. Those of the Ceylon bear and giant panda had the typically high land animal content of palmitic acid, but the bear fatty acids included 11 % of hexadecenoic acid, whilst the panda fat contained about the same proportion of ordinary or 'seed fat' linoleic acid. The baboon fat also contained a similar amount of linoleic acid, whilst its palmitic acid content was unusually low.

The range of species from which the materials were drawn is too fragmentary and restricted to permit of any general conclusions being made, and the scope for much wider research in this field is clear.

Of the two bird fats, that of the emu resembles the fats of land mammalia in many respects, but is much richer in oleic acid and somewhat poorer in palmitic acid; the fat of the grey goose was characterized by comparatively large amounts of lauric and myristic acids, but how far this is due to species or possibly to dietary conditions is at the moment uncertain.

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