19 More Thoughts on the Aquatic Ape Theory

HOW THE AQUATIC ADAPTATIONS OF MAN DIFFER FROM THOSE OF THE GORILLA AND THE CHIMPANZEE

Karl-Erich Fichtelius

SUMMARY
Bipedalism and hairlessness have often been interpreted as aquatic adaptations. Other features distinguishing man from the apes – such as differences in erythrocytes, female genital organs and temperature regulation – can be similarly interpreted.

Introduction

In seeking to establish the validity of the Aquatic Ape Theory (AAT), Hardy (1960), Morgan (1972, 1982) and Morgan and Verhaegen (1986) have sought evidence of aquatic adaptations in man by making general comparisons with other mammalian species. The most relevant differences must be expected to be those found when comparing man with his closest relatives – the apes. This essay points to three features not discussed so far.

Physical and physiological properties of blood

As one of their physical adaptations to long periods of submersion, marine mammals have a reduced number of red blood cells per unit volume. They have large blood cells, with a higher haemoglobin content per unit volume per cell than is found in land mammals of comparable size (Lenfant, 1969). In this respect it is remarkable that chimpanzees have an average of 7.3 million red cells per cubic millimetre of blood, gorillas 6.3 and humans only 5.1 million; the average size of the cells is about the same. The percentages of haemoglobin per cell are about 12.2 for chimpanzees, 13.2 for gorillas, and 18.6 for humans (Eberl-Rothe, 1960).

Various other features, related to the effective utilisation of oxygen, distinguish deep-diving mammals from land mammals: the amount of oxygen per unit volume of blood, the dissociation curve for oxygen and haemoglobin, the blood's capacity to absorb carbon dioxide, lung volume, and the volume of air that is exchanged during each breath. From the point of view of the AAT, further comparative research on man versus apes on these features would be of interest.

The vagina

The vagina of toothed whales, seals and dugongs is long and winding, and has a better developed hymen than is found among land mammals. These arrangements presumably function as a barrier, preventing water from entering the vagina. Dugongs have, in addition, a gland-like structure covering the lower part of the vagina. Even the urethra is embedded in this tissue (Harrison, 1969). A comparison with African apes shows (Eckstein, 1960):

(1) In their embryonic state females of all three species have well developed labia majora. In our species they remain large and developed throughout life, but in the ape they become vestigial in adult life, and the labia minora are clearly visible.
(2) Human females have transverse folds in the vagina, while the apes have longitudinal ones. The gorilla has some transverse folds, but not nearly so well developed as in our own species. In apes the vagina is straight; in humans it is oblique, towards the ventral side. Also, it is considerably longer than that of the others, as judged by the length of the penis (Lindblad, 1987). On average, the erect penis of a gorilla is 3 cm long, of a chimpanzee 8 cm, and of man 15 cm.
(3) The hymen occurs in humans and prosimians, but not in monkeys or apes.

The primal function of the hymen bears a relation to the seasonality of sexual activity; in the guinea-pig and some other small mammals it reseals the vaginal opening after each reproductive period. In *Homo* it is unlikely to relate to this function, considering the all-the-year-round state of receptivity in the adult female. The presence of a well developed hymen in a number of large, unrelated aquatic mammals suggests that in an aquatic medium it serves a different function.

It would appear, therefore, that the labia and the vagina of the human female are in several respects better designed than those of the ape for keeping out water and water-borne impurities.

Prevention of heat loss

To minimise the heat loss from the peripheral parts of the body and yet retain an adequate circulation of blood to these parts, numerous terrestrial mammals (Bazett *et al.*, 1948) and marine mammals (Irving, 1960; Slijper, 1979) exploit a counter-current heat exchange, the limb arteries being surrounded by veins. Humans and apes have a similar effective arrangement. But in the gorilla the veins surrounding the femoral artery are thick-walled compared with corresponding human veins. They are almost as thick as the artery itself, and presumably less

effective at taking up heat from it (Platzer, 1960). If the AAT is correct, there would certainly have been some selective pressure to diminish the degree to which surface heat loss affects the body's core temperature. Man's generic ability to do this should be compared with that of apes.

Conclusion

A comparison of relevant human anatomical and physiological features with those of gorilla and chimpanzee does not contradict the theory about the possible aquatic adaptations of *Homo*. Such systematic comparisons should be continued and extended.

REFERENCES

Bazett, H.C., Loe, L., Eisenberg, L., Day, R. and Forster, R., 1948, *Journal of Applied Physiology*, **1**, 169–83.

Eberl-Rothe, G., 1960, Blutzellen. In *Primatologia*, ed. Hofer et al. (Basel: Karger), vol. 3: 1, 1–21.

Eckstein, P., 1960, Reproductive organs. In *Primatologia*, ed. Hofer et al. (Basel: Karger), vol. 3: 1, 542–629.

Ellis, D.V., Is an aquatic ape viable in terms of marine ecology and primate behaviour? (This volume, chapter 4.)

Hardy, A., 1960, Was man more aquatic in the past? *New Scientist*, **7**, 642–5.

Harrison, R.J., 1969, Reproduction and reproductive organs. In *The Biology of Marine Mammals*, ed. H.T. Andersen (New York: Academic Press).

Irving, L., 1969, Temperature regulation in marine mammals. In *The Biology of Marine Mammals*, ed. H.T. Andersen (New York: Academic Press).

Lenfant, C., 1969, Physiological properties of the blood of marine mammals. In *The Biology of Marine Mammals*, ed. H.T. Andersen (New York: Academic Press).

Lindblad, J., 1987, *Människen, du, jug och den ursprungliga* (Stockholm: Bonniers).

Morgan, E., 1972, *The Descent of Woman* (London: Souvenir Press).

Morgan E., 1982, The aquatic hypothesis. *New Scientist*, **1405**, 17–18.

Morgan, E. and Verhaegen, M., 1986, In the beginning was the water. *New Scientist*, **1498**, 62–3.

Platzer, W., 1960, Das Arterien- und Venensystem. In *Primatologia*, ed. Hofer *et al.* (Basel: Karger), vol. 3: 2.

Slijper, E.J. 1979, *Whales* (London: Hutchinson).

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SOME CARDIAC TOPOGRAPHIC AND MORPHO-PHYSIOLOGICAL OBSERVATIONS OF THE COMMON SEAL AND OF MAN

Cornelis J. van Nie and Machteld Roede

SUMMARY

Viewed in the light of the Aquatic Ape Theory, a comparison with sea mammals may assist our understanding of features in which humans differ from other terrestrial mammals. Reported here are some cardiac adaptations to diving in pinnipeds and some similarities between man and the common seal (*Phoca vitulina vitulina*), both in general morphology and in the congenital pathology of the heart.

Introduction

Pickford (this volume, chapter 7) is right, in that mere analogies are risky proofs of evidence. Yet some data on cardiac morphology may provide information relevant to the discussion of the AAT (Hardy, 1960; Morgan, 1982). They are based on observations made by the first author during numerous dissections of man and animals – mainly cattle and pigs, but also aquatic mammals. His special interest focused on the heart and its anomalies. The second author became involved with sea mammals when she was a student of Evert Slijper, a leading authority on whales.

Man is only remotely related to the aquatic mammals, which are more closely related to predators and ungulates (see Roede, this volume, chapter 18). Yet in view of the debate on the AAT, it may be useful to report some cardiac features of pinnipeds in connection with their diving capacities, and to describe some similarities between man and the common seal (*Phoca vitulina vitulina*).

The diving reflex

Patrick (see this volume, chapter 14) and Schagatay (this volume, chapter 15) have discussed the diving reflex (Hempleman and Lockwood, 1978), which implies a bradycardia in mammals, birds and amphibia. The reflex shows great interspecific variability; the degree of bradycardia is greatest in diving cetaceans and pinnipeds, where the pulse rate may decrease from 120 to 12 per minute. The increase of the interval between the heartbeats would seem to damage the brain and heart tissue, from oxygen depletion due to the expected sharp decreases in blood pressure. To maintain an adequate mean blood pressure, parts of the aorta ascendens function as an auxiliary heart or air chamber, by means of the widened bulbus aortae and the quantity and quality of the elastic fibres in its wall. Three examples are given to illustrate the relation between morphology and function with regard to the demands of diving.

(1) In 'professional' divers like the cetaceans and pinnipeds (see Roede, this volume, chapter 18), the whole aorta ascendens functions as an air chamber. In contrast, in occasional divers like humans and dogs, that function is restricted to the aorta's proximal part, the area of the semi-lunar valves (or sinus valsalvae).

(2) In seals the development of the bulbus aortae was found to differ in relation to habitat and behaviour. Pups of the common seal start swimming and diving within eight hours of birth. The elastic fibres in the wall of their bulbus aortae are well developed; the air chamber function starts right after birth. In contrast, pups of the Weddell seal have to learn swimming and diving after a post-partum period on the rocks of at least six weeks. The development of their elastic fibres is relatively retarded (van Nie, 1985).

(3) On dissection, the number of autonomous ganglial cells in the

vicinity of the sinuatrial node in aquatic mammals (like the seal, the sea-lion and also the musk-rat) proves to be about three times higher than in terrestrial mammals, including man. The bradycardia during diving shown by aquatic mammals might be effected by the modification of sinuatrial node activity through the influence of the parasympathetic part of the autonomous nervous system (van Nie, 1986).

In these three respects, man differs from sea mammals.

Cardiac topography

Certain findings about man and the common seal are now summarised. First, there is a similarity in the spatial relationship between the heart and the great vessels, which is quite different from that in other mammals. Secondly, in both species we find the same shape and topography of the heart, its apex being directed caudally, not caudo-ventrally as in other mammals, and the cross-section of the thorax in both is dorso-ventrally flattened. In contrast, one finds latero-medial flattening in most quadrupedal species, including the fur seal (*Arctocephalus australis*). In the common seal there may be a functional relation between these specific morphological features and its typical caterpillar-like terrestrial locomotion (van Nie, 1982, 1983).

Coarctatio aortae

In humans and other mammals, many types and degrees of congenital anomalies of the heart occur. Some are predominant in one species, and others in other species. Here we focus on coarctatio aortae, a narrowing of the aortic arch near the ductus arteriosus; the stenosis may have the shape of a ring or a funnel. Coarctatio aortae – extremely rare in pigs and cattle – is rather common in seals; we found it in 4 out of 38 dissected seals. The incidence in man is 0.08 per cent of live births. In the seal, coarctation would seem to support the function of the bulbus during diving by ensuring a sufficient blood supply to the heart and brain. In man, the effect of coarctation might well be similar – that is, an increase in blood-flow to the brain. During embryonic life, coarctatio aortae is a necessary condition; accordingly, it is present in all humans before birth. It ensures the proper intra-uterine development of the brain. In adults one of the first symptoms is the presence of cold feet, due to the decreased circulation in the lower half of the body.

Lévi-Strauss has expressed the value of myths for modern science. This may be illustrated by reference to a Norwegian myth about sailors and seals. Sailors believe that seals are sinful sailors. Punished by the gods for their sinful life, they are condemned to become seals, in a hairy pelt and at the mercy of water, wind and tide. It may happen, though, that such a

'seal' saves the life of a sailor in the agony of near-death. Then the seal changes into a beautiful princess, and becomes the sailor's bride. These ladies are said to have lovely dark eyes and bodies, but their feet are always much colder than those of normal girls. This myth thus seems to tell the clinical history of coarctatio aortae in man.

Conclusion

We hypothesise that the initial aquatic functional adaptations acquired by Miocene ancestral hominids might have included some intrathoracic circulatory features.

REFERENCES

Hardy, A., 1960, Was man more aquatic in the past? *New Scientist*, **7**, 642–5.

Hempleman, H.V. and Lockwood, A.P.M., 1978, *The Physiology of Diving in Man and Other Animals* (London: Edward Arnold).

Lévi-Strauss, C., 1964–8, *Mythologique* (Paris: Plon).

Morgan, E., 1982, *The Aquatic Ape* (Souvenir Press: London).

Nie, C.J. van, 1974, Some reflections about the relation of the semilunar valvular rings of the heart and the transposition of the great vessels in animals. *Proceedings of the 9th Congress of the European Association of Veterinary Anatomists*, Toulouse.

Nie, C.J. van, 1982, De morfologie en de congenitale pathologie van het hart van de gewone zeehond (*Phoca vitulina vitulina*). Zeehonden Symposium. *Tijdschrift Diergeneeskunde*, **107**, 368–74.

Nie, C.J. van, 1983, A comparative study of the morphology and the topography of the heart of the *Arctocephalus australis* (Fur or Ursine seal) and the heart of the *Phoca vitulina vitulina* (Common or Harbour-seal) in their relation to the type of locomotion. *Aquatic Mammals*, **10**, 79–82.

Nie, C.J. van, 1985, The bulbus aortae (aorta ascendens) in the growing common seal (*Phoca vitulina vitulina*) (a morphological approach). *Aquatic Mammals*, **11**(3), 71–4.

Nie, C.J. van, 1986, The sinuatrial node and its adjacent autonomous ganglia cells in aquatic mammals (a morphological approach). *Aquatic Mammals*, **12** (3), 92–4.

Patrick, J.M., 1991, Human respiratory adaptations for swimming and diving. (This volume, chapter 14.)

Pickford, M., 1991, Does the geological evidence support the Aquatic Ape Theory? (This volume, chapter 7.)

Roede, M., 1991, Do aquatic mammals provide support for the Aquatic Ape Theory? (This volume, chapter 18.)

Schagatay, E., 1991, The significance of the human diving reflex. (This volume, chapter 15.)

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THE ANSWER: THE AQUATIC APE THEORY AND THE SAVANNAH THEORY COMBINED

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SUMMARY

After brief comments on Wheeler's statements about cooling down in the sea and the loss of fur (this volume, chapter 13), it is proposed to consider the Aquatic Ape Theory and the Savannah Theory as complementary, and not mutually exclusive.

The answer

One of the interpretations of the Aquatic Ape Theory proposes that this ape lived on the shore and frequently went into the water to play, to swim and to collect food, as modern humans like to do when on holiday (Ellis, this volume, chapter 4; Richards, chapter 6). If we adopt this view of the aquatic ape, Wheeler's counter-evidence (chapter 13) – in support of the Savannah Theory – needs some re-evaluation.

First, some remarks about Wheeler's graphs (Figure 13.2) which show that humans cannot produce enough energy to maintain their body temperature in water. As many of us may know from experience, in the Mediterranean, when day temperatures in summer are between 25°C and 35°C and the water temperature is between 22°C and 26°C, it is perfectly possible to be in the water for several hours a day without danger from the point of view of survival. Of course, we cannot, as Wheeler shows, stay in the water for hours at a stretch, but we can alternate periods in and out of the water the whole day. Every time we go into the water we cool down, and use up some energy in trying to keep the body temperature up. When we leave the water we stay in the sun to get warm, and after a while we can go in again. It is not necessary to keep our body temperature constantly at 37°C; we can afford to cool down peripherally for a short time. The sun, which causes such a strong selection pressure for the savannah, according to Wheeler, will provide the heat to raise our body temperature again to the normal level. By eating enough food – we would need to eat more than when we do not go into the water at all – we will be able to replenish the calories lost during the periods in the water.

Furthermore, in his Savannah Theory Wheeler suggests that a selection pressure exerted by solar heat made our ancestors lose their fur and acquire eccrine sweat glands for keeping the body temperature low by transpiration. To compensate for the water loss by transpiration, he suggests, our ancestors drank water from freshwater sources that were always nearby on the savannah. If there was always water nearby, would it not be more likely that the sun's heat made our ancestors use that water to get wet, so that the evaporation of the water on the skin kept the body temperature low? They would not have needed to develop sweat glands and a furless skin if there was always water nearby in which to cool down.

I accept Wheeler's point that the loss of fur would not have been brought about during an aquatic phase in the evolution of our ancestors merely because they were too small. There exist modern mammals which spend some or much of their time in the water and still have fur. Hence, another explanation is needed for the loss of fur. However, there remain certain human features – such as the diving reflex, tears and perhaps the eccrine sweat glands – which seem to need to be explained

by an aquatic phase in our early evolution. Therefore, I want to propose a combination of the Savannah Theory and the Aquatic Ape Theory.

The 'baboon marker', mentioned by Morgan (this volume, chapter 2), strongly suggests that for a while our ancestors were isolated from the African savannah animals. If a small group of African ape-like creatures became isolated – perhaps trapped on Danakil Island (LaLumiere, chapter 3) – it can be imagined that a rapid evolution of characteristics, quite different from those of the original species, took place. This often happens when a small group gets isolated in a small place: the result of a founder effect, no gene flow, genetic drift and slightly different selection pressures deriving from a slightly different environment. Imagine a small population of our ancestors who lived isolated on a small island, always very near to the sea. They would frequently go into the water, probably to escape not from predators but from the sun's heat, and to collect some easily available food. In the light of evidence showing that certain other primates like water, I do not think that there is any necessity to believe that our ancestors would have been hydrophobic. If they spent much time in the water it would have been advantageous for them to develop eccrine sweat glands and tears for salt excretion. If they had to dive for their food – urchins, molluscs, crustaceans, anemones and so on, which could be easily collected in shallow water near the shore – they would have benefited from a diving reflex. Perhaps if they spent much time swimming, the angle between their spine and their hind limbs would have become straighter – which later became a preadaptation for bipedal locomotion.

Then, when the island was joined to the mainland again, this group of 'different' apes spread on to the savannah. If they had been preadapted with eccrine sweat glands, which here happened to be useful for thermoregulation, and if another preadaptation had been a more upright posture, they could have become bipedal, furless, sweating creatures, as in Wheeler's Savannah Theory. They would probably not even have had to wait for the island to join the mainland: also on this island with a hot (savannah) climate it would have been advantageous, during the periods spent out of the water, to become bipedal and furless with eccrine glands.

Conclusion

In my opinion the Savannah Theory and the Aquatic Ape Theory are complementary, not mutually exclusive. We need the Aquatic Ape Theory to explain the diving reflex and, perhaps, tears. On the other hand, we probably need the Savannah Theory to explain the loss of fur. But here again we need the Aquatic Ape Theory to make the loss of fur possible as a result of the preadaptation represented by eccrine sweat glands. I would like to conclude that we need both theories to explain the first steps in our evolution.

REFERENCES
Ellis, LaLumiere, Morgan, Richards and Wheeler, chapters 4, 3, 2, 6 and 13 respectively, this volume.

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THE SECOND CRISIS

Erika Schagatay

SUMMARY
When the Miocene drought changed into a moister climate, the increase in terrestrial productivity may have been paralleled by a decrease in reef productivity, as a result of greatly increased sediment transport to the reefs by run-off rainwater. Also, changes in sea level may have damaged the reefs. These alterations in the coastal habitat and decline in its edible marine life may have forced the apes to explore the terrestrial environment and finally to abandon the sea.

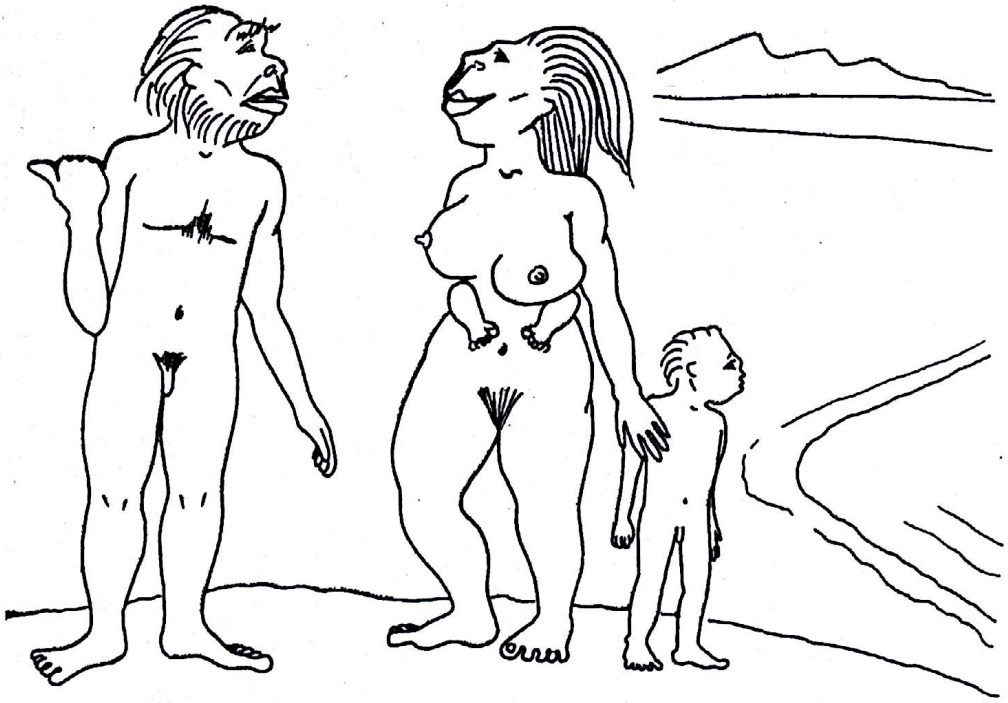

Figure 19.1 When food got scarce on the dying reefs the aquatic apes started to explore the river beds and finally left the sea.

The enigmatic question

The climatological changes in East Africa, having caused forests to retreat and savannahs and deserts to expand, may have led to a crisis for our arboreal ancestors. At the end of the Miocene East Africa was largely deforested but, because of ideal conditions for coral growth, its coasts were lined with rich reefs. It is plausible that a group of apes learned to utilise the marine resources, and over a long period of time became semi-aquatic. The diverse and easily accessible food resources might even have

been partly known to some ape populations before the land became inhospitable to them. But once the apes had become adapted to the aquatic environment, what caused them ultimately to leave it?

Writers on the Aquatic Ape Theory conclude that, as soon as favourable changes permitted, the apes returned to a terrestrial life. But we need to go further, and try to explain why the hypothetical aquatic ape, highly dependent on the coral reef for food and shelter, returned to the land. Morgan (1982; this volume, chapter 2) suggested that the aquatic ape was well equipped to exploit the new conditions on land, as brought about by the end of the drought period. Indeed, it could be considered to have been preadapted to develop some of the qualities which would be of use to it later on land, though during the preceding phase the aquatic ape was equipped to utilise the reef habitat. At the end of the aquatic phase I picture a biped who could walk well but not yet run fast; a user of the first primitive tools, though not a skilled hunter.

LaLumiere (1981; this volume, chapter 3) suggests that the aquatic apes, after having been isolated on Danakil Island for at least 1.5 to 3 million years, walked back to spread out over Africa after the island had been reconnected to the mainland by the regression of the sea. It is indeed possible that selective pressures on a population of apes isolated on a geographical island caused them to start exploring marine resources; the geological history of the Danakil horst makes this an interesting proposal. But it provides no explanation of why the aquatic apes abandoned the sea. Morgan's suggestion that the sea may have abandoned the ape is interesting, but remains speculative when based on sea-level fluctuations alone. When the sea retreated, the apes could have followed the slowly retreating shore lines as deeper parts of the reef developed.

So what else could have contributed to the end of the aquatic period? There seems to be agreement that something happened at the end of the prolonged Miocene drought. To find an answer to this question, raised by Morgan as well as by some critics of the AAT as one of the most puzzling ones relating to this theory, one has to examine what can actually happen when a dry, tropical climate changes into a moister one.

A possible explanation

During a period of extremely limited rainfall, the soil loses most of its ability to absorb water, resulting in a massive surface run-off when precipitation increases. As a result, silt and sand are transported by the rainwater to the sea. A drastic increase in sediment outflow may suffocate the reef, since optimal conditions for reef-building corals are warm, saline, light, well aerated (oxygenated) water free of suspended sediment. More-over, immersion of coastal flora and transport by rainwater of organic material to the sea would have set off rotting processes and subsequent de-oxygenation of coastal waters (Stock, 1990). Finally, the

supply of fresh water after a heavy downpour may have caused drastic local changes in salinity which could have affected the reef.

Machteld Roede suggests that sea-level fluctuations may also have contributed to reef destruction. The increased rainfall in the Miocene period and subsequently decreased evaporation at the surface of the sea due to cloud cover, may initially have led to a slight rise in sea level. If this rise exceeded the rate of coral growth, it could have had an inhibitory effect on reef development, as coral growth mainly takes place just below the water surface where light conditions are optimal. On the other hand, when the sea finally retreated it would have caused reef destruction above the new neap flood level. Corals are sensitive to air exposure longer than the usual inter-tidal period, and start dying after six hours of standing clear of water (Roos, 1971). The rise and fall of islands and reefs is well documented (Stock, 1990), and frequently used by geologists to reconstruct Ice Age cycli. Fossil reefs could possibly reveal whether such a scenario fits the AAT. It may be that massive reef destruction, due to the outflow of sediment (and so not correlated to Ice Age cycli), can also be detected in fossil reef series.

Thus, the changes brought about by the end of the Miocene drought period affected not only the environment on land, but also, to a large extent, the conditions in the marine ecosystem at its shores. The rapid increase in land productivity when seasonal rains returned was paralleled by the diminishing productivity of the coastal reefs. Such changes would have had a large influence on the habitat of the aquatic apes. When parts of the reef were damaged or destroyed, the apes could have started migrating in search of undamaged areas where drainage from the land was low. But when the productivity of the entire coastal habitat gradually diminished, the apes would have been forced to explore the increasingly rich river-beds and inland areas near the shore in search of alternative sources of food. Subsequently, they would have left the seashore, adopting a mainly terrestrial mode of life.

Conclusion

While drought was the first crisis for our ancestors, forcing them to adopt a semi-aquatic life, the return of the rains was their second crisis, forcing them once more to change their way of living in order to survive – and to return to the land.

REFERENCES

LaLumiere, L.P., 1981, Evolution of human bipedalism: a hypothesis about where it happened. *Philosophical Transactions of the Royal Society of London*, **B292**, 103–7.

LaLumiere, L.P., 1991, Evolution of genus *Homo*: where it happened. (This volume, chapter 3.)

Morgan, E., 1982, *The Aquatic Ape* (London: Souvenir Press).

Morgan, E., 1991, Why a new theory is needed. (This volume, chapter 2.)
Roos, P.J., 1971, The shallow-water stony corals of the Netherlands Antilles. *Studies Fauna Curaçao Caribbean Islands*, **37**, 1–108.
Stock, J.H., 1990, *Insular groundwater biotas – a biogeographic synthesis.* (Valedictory lecture, University of Amsterdam, 22 October.)

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HUMAN SEXUAL DIMORPHISM: A SPECULATIVE APPROACH

Erika Schagatay

SUMMARY
In this essay a possible aquatic origin of sexual dimorphism in human fat distribution is discussed. It is proposed that the relatively large, fat-padded breast of the human female may primarily have evolved to facilitate nursing in the water. It is suggested that her protruding buttocks and hips, combined with a slim waist, may have evolved to enable the baby to cling on to the naked mother; and that the origin of the sexual dimorphism in overall fat insulation may be sexually determined behavioural differences deriving from an aquatic phase of hominid evolution.

Introduction

Features of sexual dimorphism, and sex differences in general, have often been a matter debate among human evolutionists. Some of these features have been discussed by Morgan (1972; this volume, page 15), Pond (this volume, page 209) and Fichtelius (1985) in the context of the AAT. I share their view that we have to concentrate on finding functional explanations for features which later may have been sexually selected for. In this essay, a personal speculation about the origin of sexual dimorphism in the distribution of human fat will be given.

Breasts

Morgan links this distinctively human attribute, the fat-padded breast, to the Aquatic Ape Theory by explaining how the aquatic mother – on land, with the baby on her lap – needed some arrangement for lowering the nipple to the baby's mouth. However, this is the way in which the mother chimpanzee often breast-feeds her baby, even though her breasts are of an entirely different shape. This gives rise to two questions:

(1) Does the usual shape of the nursing human mother's breast offer a firm grip to a baby's hands?
(2) Did our presumed aquatic mother have to leave the water to feed her baby?

The answer to the first question has to be a categorical no. Nursing mothers usually have round, firm breasts. Especially when full of milk, the taut breast does not offer any grip for tiny baby hands. I believe that

holding on to a mother chimpanzee's slack nipple is easier for any baby than grabbing a human breast. The aquatic ape females may not have lived long enough to acquire the more tube-like, grippable swag-breasts required for the land-based theory.

When answering the second question, we have to bear in mind that a mother who carries her baby with her normally feeds it as soon as it gets hungry. This means feeding at least every two hours when the child is small (no matter what was recommended in the West during the first half of this century). This is the natural way still practised in many parts of the world; our aquatic mother probably fed her baby in the same way.

We now have to imagine the situation of a food-searching aquatic ape mother. She has come far from the place where she entered the water in her search for food. Suddenly the baby starts whining. Before she can reach the shore, the baby is howling, and sooner or later she will try to breast-feed it at sea.

This innovation must have spread through the population. Babies with mothers having slightly more fat padding around the nipples could drink more milk (and less sea water) than did other babies, and consequently grew faster and had a better chance of surviving. Mothers not succeeding in breast-feeding at sea lost valuable food-seeking time when they had to swim ashore, and were not able to feed their babies as efficiently as those feeding them at sea. After a great many generations, mothers usually fed their babies at sea, and males reproducing with large-bosomed females fathered more children. This led to sexual selection for this feature, which continued on land where the feature lost its original, functional value, and in extreme cases is even harmful to the owner. This answers my second question: the aquatic ape mother did not have to leave the sea to feed her baby, if there were other reasons for staying in the water. Of course, the aquatic mother fed her baby on land too. The child could feed comfortably from her type of breast there as well, when held by her or lying down beside her on the warm sand.

Now it is possible to explain the otherwise surprising fact that we have the same breast shape as sea-cows, but one different from the apes. It could be because our foremothers often fed their babies in the same way as sea-cows have been reported to do: floating vertically in the water while holding their babies in their arms. In both cases the breasts float, giving the baby good access to the nipple. The breasts also form a good seal against the baby's mouth, letting no water in, in spite of waves or accidental submersion. It is even possible to suckle a baby totally submerged (Tjarkowskij, 1982), although I do not think this was purposely practised among the aquatic apes.

By accepting an aquatic explanation instead of the land-based one, we also get an answer to why round, firm breasts, rather than tube-like ones, became ideal in the eyes of males.

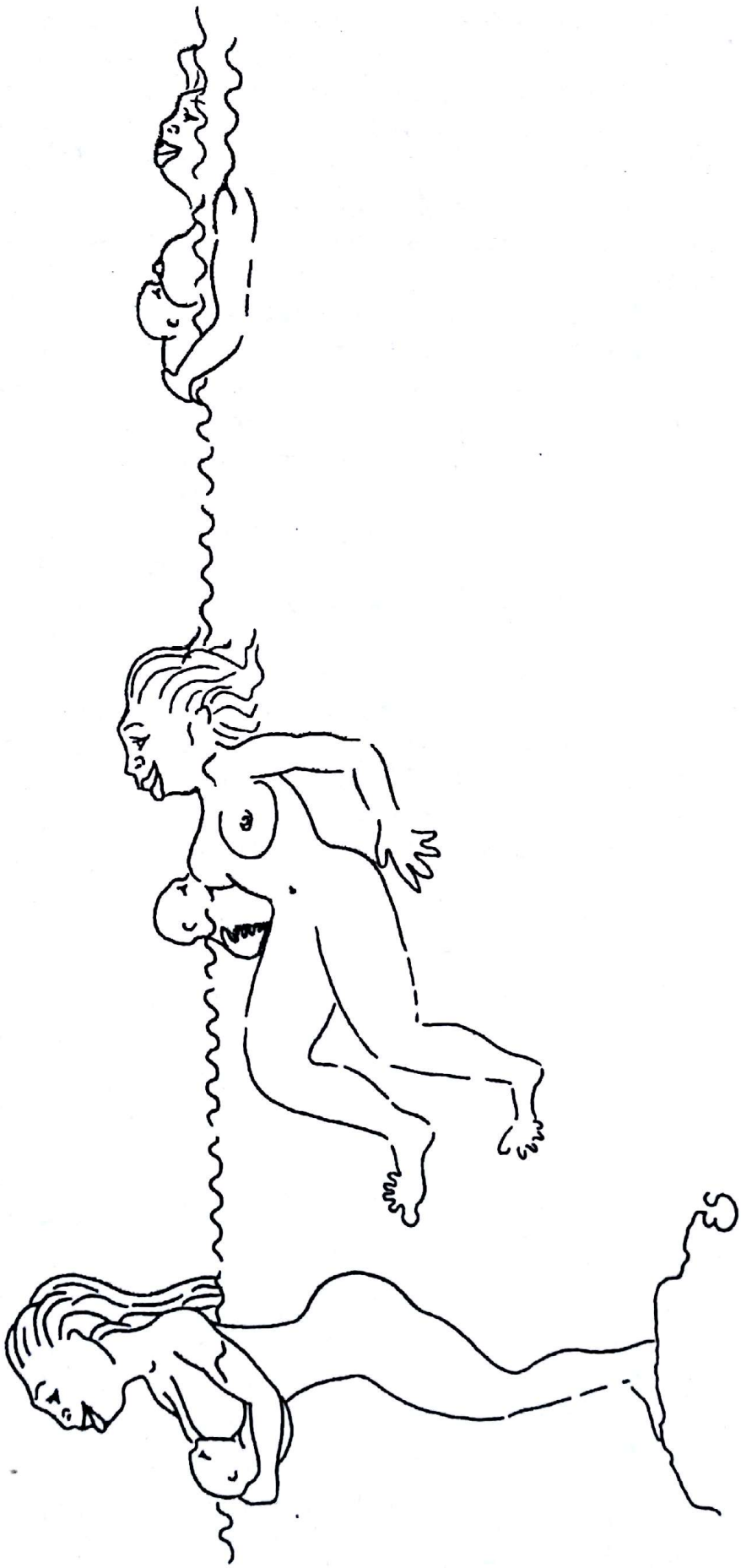

Figure 19.2 Three positions which could be used by the aquatic ape mother when feeding her baby at sea. In all situations the floating breast assured the baby easy access to the nipple, and the fat-padding made a watertight seal with the baby's mouth. The fat also kept the breasts well insulated and warm. It was the ideal solution for mother and child.

Buttocks

One of the most distinctive features of the human female's body is the buttocks, which are not nearly as well developed in the male or in any other primate. The fact that a woman needs a wide pelvis in order to give birth to large-headed babies is well known, and well developed muscles are needed to keep the body in an upright position. But why is this feature exaggerated by a deposit of fat in the female? For streamlining and insulation, this fat would serve a better purpose if distributed around the belly, as in the male.

In *The Descent of Woman* Morgan (1972) supposes that the buttocks were necessary to protect the female from getting sand and dirt into her genitals when sitting on the beach. But apes also often sit in this position on the ground (Goodall, 1971). Although such protection might have been one benefit of the feature, I think it had another origin.

When discussing the pros and cons of the aquatic adaptations on land, one of the most problematic innovations is that of nakedness – not only for adults, whose protection against the sun and hence their adaptation for heat control thereby decreased, but also for the babies who were used to clinging on to the mother by grabbing her fur. A formerly suggested solution to this problem is that the human female acquired long head-hair to give her baby a hold. But while the mother's hair would be very helpful to the child when both were in the water, it was not enough for babies clinging to their mothers on land. Another innovation was needed to keep the baby from falling off the mother. This is where the buttocks – protruding not only from the sides but also from the back – acquire their role.

Today this feature is particularly pronounced in some African populations, where the children are carried on the backs of their mothers. An extreme form exists in Bushwomen, where the buttocks form a flat, almost horizontal, 'shelf' serving this purpose very well (Figure 19.3 (b)). Even though most women are less extreme in this respect, when a pregnant woman puts on weight she puts it in large part on her hips and buttocks.

I think the mother's protruding buttocks, in combination with a slim waist and long head-hair, offered our water-baby the support needed for it to stay on its mother's back by itself when necessary. When climbing in and out of the water, the mother had to use both her hands and her feet to get through the waves and over the reef edge without losing balance, and she could not give the baby much assistance. On land the arrangement freed her hands for other tasks.

Again, there is a corresponding ideal image of a woman among modern men: a slim waist together with round hips give her the curved configuration desired in so many cultures. Stone Age paintings and carvings from various parts of the world often display women with enormously protruding, shelf-like buttocks (see Figures 12.1 and 19.3(a)).

In Western culture the importance of having a slim waist was so stressed at one time that to be considered attractive women had to wear corsets, often combined with built-up dresses, emphasising the buttocks or hips (Figure 19.3(c)).

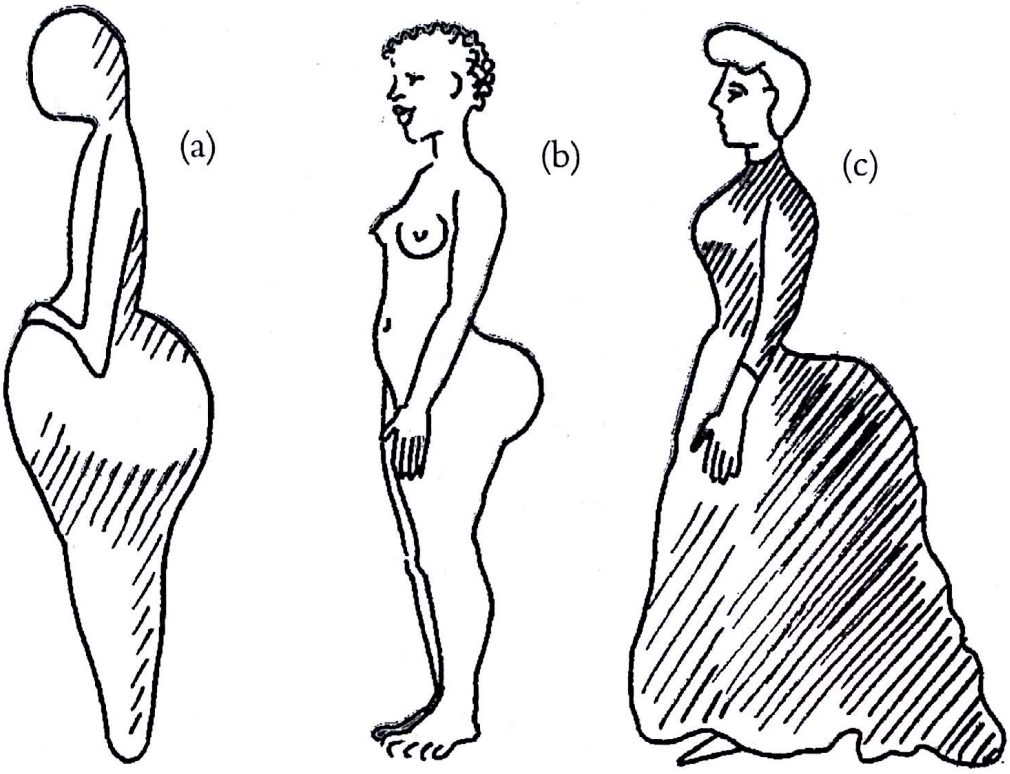

Figure 19.3 Stone Age torso, steatopygous Bushwoman and fashionable nineteenth-century lady.

'Blubber'

Why is it that men and women not only have their body fat distributed in different ways, but also have unequal amounts of it (Pond, this volume, chapter 12)? Women usually have a relatively thick layer covering the entire body surface – much like the blubber of marine mammals – while men have most of it in their belly area. Women consequently have a better insulation in water, which explains why they often survive boat accidents in which men die from the cold. This seems to suggest that women are better adapted to marine life than men are.

When discussing aquatic adaptations, Hardy (1960) emphasised the streamlining of the female body. But is not a somewhat plump man more streamlined? It has already been suggested that the females acquired their body curves not primarily in order to become better swimmers, but to give better support to their babies.

There is no evidence of sex differences in the diving reflex or in breath-holding time. Nevertheless, when occupied in the same activities as men, women can stay longer in the water without becoming

hypothermic. This may be the reason for the tradition of sponge- and pearl-divers being mainly females (Ama and Haenyo peoples, in the cold seas between Korea and Japan). Women are also better at long-distance swimming than are men, while men are faster at short distances. I think the Aquatic Ape Theory can help us explain this difference. Again, it has to do with making the female a better mother.

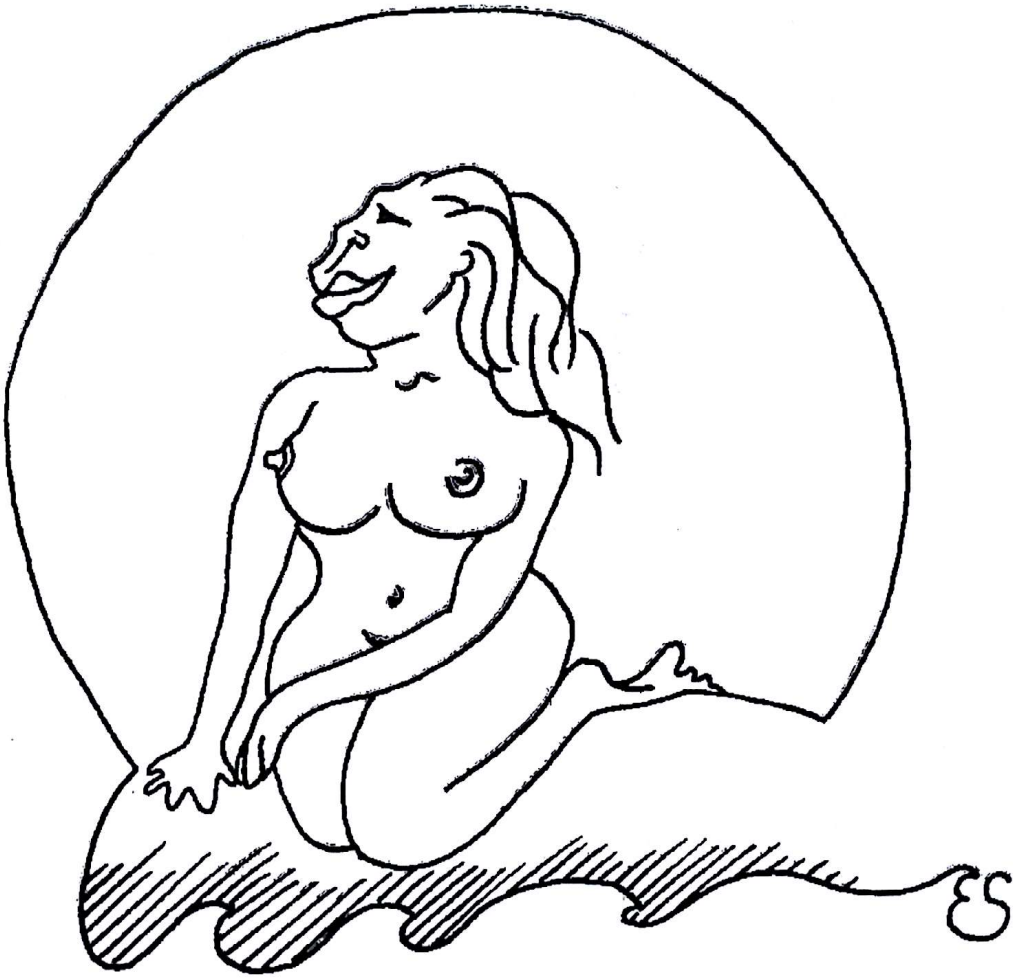

Figure 19.4 At the end of the aquatic phase Ms Missing Link may have looked something like this.

While most aquatic ape females must have spent their days slowly swimming about at the pace of their children, collecting food on the reef, the males may have led much more mobile lives. Apart from collecting slow-moving seafood, the male might have been active in hunting turtles and other moderately fast swimmers. The muscle heat produced by fast swimming may have been sufficient to keep him warm in the relatively warm tropical waters; in contrast, the aquatic mother never swam fast enough for it to matter. The male could get into and out of the water much more easily than the baby-carrying female, and he may not have spent such long periods at a time in the water.

When there were predators on land the male could defend himself by approaching the threat in shallow water, throwing rocks, then quickly retreating into deeper water. For the aquatic mother this would have been out of the question, and in these situations she had to stay out of reach and spend extended periods of time in the water. As suggested, feeding the baby at sea offered her no problem. Of course, the baby would get cold before the mother, but when this happened the mother could move to a place where the water reached to her waist and the baby could warm up in her arms or on her back. The female could stay for extended periods in this position, thanks to the particularly well developed fat insulation in her lower body parts. This distribution of fat also gave her good buoyancy for floating vertically when breast-feeding in deeper water.

Conclusion

Thus, the blubber-like fat layer of the modern female does not necessarily indicate a difference in the degree to which the sexes were adapted to water, but a difference arising from different behaviour while in the water. Aquatic ape males and females might very well have spent the same amount of time per day in the water.

REFERENCES

Fichtelius, K. 1985, (*Hur apan miste pälsen och kom upp på två ben*) (Stockholm: Akademilitteratur).
Goodall, J., 1971, *In the Shadow of Man* (London: Collins).
Hardy, A., 1960, Was man more aquatic in the past? *New Scientist*, **7**, 642–5.
Morgan, E., 1972, *The Descent of Woman* (London: Souvenir Press).
Morgan, E., 1982, *The Aquatic Ape* (London: Souvenir Press).
Pond, C.M., 1991, Adipose tissue in human evolution. (This volume, chapter 12.)
Tjarkovskij, I., 1982. In *Vatten Barn*, E. Sidenbladh (Stockholm: Akademilitteratur).