COMPARATIVE PSYCHOLOGY BY ANIMAL

NO.8 - OCTOPUS

KEVIN BREWER

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"Comparative Psychology By Animal" is a series of booklets which aims to cover the topics within comparative psychology by focusing on specific animals. Each booklet will concentrate on specific issues that are relevant to that species, whether mammal, bird, amphibian/reptile, insect, or fish.

There will also be general discussions of the topics and different strategies available to the animals. All of the information is assessed from the point of evolutionary costs and benefits of a particular behaviour.

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COMPARATIVE PSYCHOLOGY

Comparative psychology is the study of non-human animal behaviour, usually, but not necessarily, to apply the results to understanding human behaviour. Thus everything revolves around the evolution of behaviour.

Evolution can be reduced to three key aspects, and all other behaviour is an offshoot of these:

- Survival from predators;
- Obtaining food/prey;
- Reproduction.

Different species will have evolved different strategies in order to do these three key things. In many cases, it is a delicate balance between getting food, and surviving in order to reproduce and pass the genes to the next generation without being eaten.

It could be better to hide and eat less because predators won't find them, yet there is a need to advertise their presence to mates.

Table 1 shows some of the main topics in comparative psychology and how they relate to the three aspects of evolution.

EVOLUTION

Evolution is the cornerstone of understanding non-human behaviour (and human behaviour, according to Evolutionary Psychologists). It is based around two central concepts, proposed by Charles Darwin [1]: natural selection and sexual selection.

NATURAL SELECTION

This is the idea of the survival of animals within a species with particular traits that give them an advantage compared to others. This behaviour is "adapted", and is well suited to the environment that the animal lives in. These "fit" animals will survive and leave more offspring, which means the spread of "adaptive traits" in that species.

For example, running faster is an adaptive trait for prey being chased by fast predators (figure 1).

[1] Complete works of Darwin at http://darwin-online.org.uk/

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	SURVIVAL FROM PREDATORS	OBTAINING FOOD/PREY	REPRODUCTION
SEXUAL SELECTION			Advertising good quality of genes; different strategy for males and females of species
PREY-PREDATOR RELATIONS	Evolution of strategies to stay ahead of predator or catch the prey		
FORAGING		Optimal input of energy for less output and risk of predation	
TERRITORIALITY		Resources to survive	To attract females and discourage competitors
MATING STRATEGIES			Mating with one partner or more, or not at all
GROUP BEHAVIOUR	"Selfish herd"	"Group hunting"	Ease of availability of mates
COMMUNICATION	"Illegitimate receivers" ie: predators		Locating mates

Table 1 - Main behaviours in comparative psychology and how they relate to the key aspects of evolution.

EXAMPLE - Each animal has two offspring:

CURRENT SITUATION	FUTURE SITUATION
Majority - animal A: Runs slow**; 2 offspring - 1 survive = 2 offspring	Few offspring in subsequent generations → 1 survive = 2 offspring
Minority - animal B: Runs fast*: 1 offspring - 2 survive = 4 offspring	Many offspring in subsequent generations → 4 survive = 8 offspring

KEY: * adaptive trait = run fast; ** non-adapt = run slow; each animal has 2 offspring

Figure 1 - Example of natural selection for adaptive traits.

More formally, natural selection depends on three principles (Dowling 1994):

i) Principle of diversity - there are a large number of variant forms of the same species (known as members of the population).

ii) Principle of interaction - these variant forms interact with the environment to see which "fit"; eg: animals that breathe air will not "fit" a permanent underwater environment.

iii) Principle of differential amplification - the variants that "fit" will spread at the expense of those who don't "fit"; ie: more offspring.

In terms of leaving offspring, animals will have evolved different strategies in relation to fecundity and viability. The first term relates to the number of fertilised eggs, and viability is the fertilised egg's chances of surviving (table 2).

	FECUNDITY	VIABILITY	EVOLUTIONARY STRATEGY
FISH	High	Low	Many eggs laid but few survive
MAMMAL	Low	High	Few or single eggs fertilised but most survive

Table 2 - Examples of fecundity and viability.

SEXUAL SELECTION

The best strategy for passing the genes into the next generation will vary between the male and female of the species. The male is able to produce many sperm, and so can theoretically have as many offspring as mates found.

But the female is restricted, in most species, by giving birth to the offspring. Thus she has more invested in its survival (table 3).

Different species behave in different ways depending upon their environments, but generally the example in table 3 is the common strategy of sexual selection. "Female choosiness" has led to the evolution of males who compete, in some way, to show the female that their genes are best for mating. This competition involves fights, "shows of quality" (eg: ornaments like a peacock's tail), or the collection of scare resources to give to the

female ("resource-holding power"; RHP).

EXAMPLE - Male mates with ten females, who have one offspring each in the breeding season

	OFFSPRING	STRATEGY
MALE	10 fathered; can afford some not to survive	Find many female mates ie indiscriminate; little concern for post-natal care
FEMALE	Each female has one offspring and thus survival important	Female invests time and effort in survival, but must exercise choosiness about male ie only mate with male who has "best genes"

Table 3 - Sexual selection and strategies for males and females.

The ideas of evolution from Charles Darwin are based upon the survival of the individual. But Dawkins (1976), more recently, has suggested that it is the survival of the genes that matter. For example, a mother who sacrifices herself for her three offspring will guarantee three copies of half of her genes survive. This has an evolutionary advantage over the survival of the mother at the expenses of her offspring. This has led to the focus on "inclusive fitness" (the survival of the individual and their biological relatives).

INTRODUCTION TO THE OCTOPUS

Octopuses are molluscs (box), like clams and oysters, but they have lost their external shells during evolution. In exchange, a central nervous system has developed which is the most complex of invertebrates, and equal to many vertebrates (Stewart 1997).

Phylum: Mollusca

Class: Cephalopoda

Order: Dibranchiata

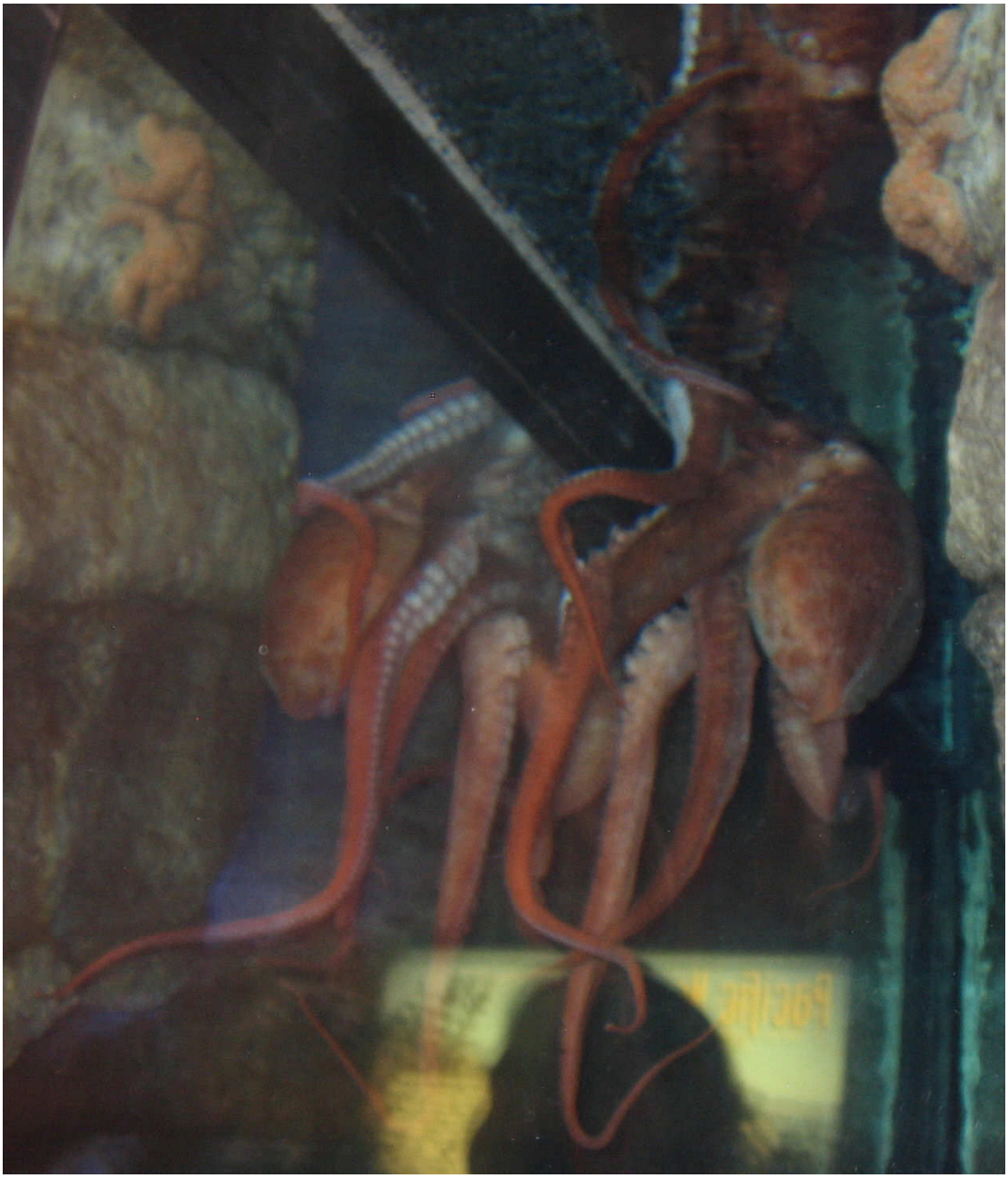
Suborder: Octopoda

There are between 150 to 200 species of octopus varying in size and lifespan from the pygmy species at an arm span of 2 inches (5 cms) living for 6 months to the Giant Pacific octopus (Octopus dofleini)(figure 2) (31 foot/9 metres; 600 lbs/270 kgs at the largest) living for three years. The common octopus (Octopus vulgaris) is most researched, weighing 50 lbs/22 kgs and having an arm span of 10 foot/3 metres (Stewart 1997). Table 4 lists some other examples of octopuses and size.

OCTOPUS	AVERAGE ARM SPAN
O. arborescens	2 inches/5 cms
O. hongkongensis	30 foot/9 metres
O. apollyon	28 foot/8 metres

Table 4 - Examples of octopuses and arm span size.

Octopuses differ from the best-known other member of the Cephalapoda, squids, in lacking an extra pair of long tentacles, and the suckers being different (Burton and Burton 1976).



(Source: WingedWolfPsion)

Figure 2 - Giant octopus

MATING AND PARENTAL CARE

There are different mating strategies used by males and females of different species of the animal kingdom (table 5).

The octopus is a solitary animal. There is no parental care as, in many species of octopus, the mother dies after the eggs hatch through lack of food from brooding the eggs (Stewart 1997). The father has no contact with the mother after meeting.

MALE	
1. monogamy: one partner for breeding season	
a. mate-assistance monogamy	male assists female in child-rearing
b. mate-guarding monogamy	female dispersal
2. polygyny: one male with multiple females	
a. female defense polygyny	male defends cluster of females
b. resource defense polygyny	male defends resources and females come
c. Lek polygyny	male defends territory and females come to mate only
d. scramble competition polygyny	**males find scattered females**
FEMALE	
1. monogamy	
a. female-enforced monogamy	male keeps other females away and assists in child-rearing
2. polyandry: one female with multiple males	
a. fertility-insurance polyandry	greater fertilisation of eggs
b. better sperm polyandry	genetically diverse sperm
c. more material benefits polyandry	more resources from males
d. more paternal care polyandry	more males help in child-rearing

(After Alcock 1993)
Bold = mating strategy used by octopuses

Table 5 - Types of mating strategy.

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There is little courtship display by the male, and mating involves the male extending the hectocotylus arm into the female's gill cavity to deposit the spermatophores. About a week later, the female lays about 150 000 tiny eggs. The mother broods the eggs for several weeks (Burton and Burton 1976).

The behaviour of caring for the offspring by the mother and/or the father varies between species (table 6).

	FEMALE STAYS AFTER BIRTH	FEMALE LEAVES AFTER BIRTH
MALE STAYS AFTER BIRTH	Equal investment by both partners; monogamy	Male greater investment than female; sex-role reversal
MALE LEAVES AFTER BIRTH	Multiple partners for male; female greater investment than male	**Multiple partners for male; many eggs must survive**

(Bold = octopus's strategy)

Table 6 - Different parental care decisions and mating strategies.

The patterns of parental care vary between species based on the amount of parental investment by each sex. "Investment" is seen as anything done by a parent to increase the chances of the survival of that particular offspring, which is at the expense of the parent's ability to invest in future offspring (Trivers 1972). Thus the parent who has invested more tends to care for that offspring, while the parent with the least investment may desert.

Maynard Smith (1977) views the relationship between the parents as a "game" (as in "game theory") - an assessment of costs and benefits of staying or deserting (table 7).

AMOUNT OF INVESTMENT	FEMALE MORE THAN MALE	MALE MORE THAN FEMALE	EQUAL
WHO CARES FOR YOUNG	MALE	FEMALE	JOINT/BOTH DESERT

Table 7 - Strategies for parental care based on parental investment.

The decision to desert or stay and care for the offspring depends on a number of factors (Maynard Smith

1978):

- Effectiveness of parental care by one versus two parents.
- The chances of the deserter being able to mate again.
- The security of paternity for the male.
- The age of the offspring.
- Whether fertilisation is internal or external.

The number of offspring and the reproductive strategy of the species can be viewed as "r-strategy" or "K-strategy" (MacArthur and Wilson 1967) (table 8). Octopus are an example of the former.

	"r-strategy"	"K-strategy"
OFFSPRING	many	few
PARENTAL INVESTMENT	low for each one	high
INFANT MORTALITY	high	low
LIFESPAN	short	long
SPEED OF DEVELOPMENT	rapid	slow
REPRODUCTIVE AGE	early	delayed
BODY SIZE	small	large
POPULATION SIZE	variable	stable
COMPETITION	lax	keen
OVERALL	high productivity	high efficiency

(Octopus = "r-strategy")

(After Daly and Wilson 1983)

Table 8 - Comparison of "r-strategy" and "K-strategy" for reproduction.

Table 9 brings together the advantages and disadvantages of the different mating and parental care

strategies used by octopuses.

MALE - CONTACT AT MATING ONLY

Advantage

1. Females widely spread so ideal for male to mate with any females found as he moves around.

2. Opportunities to mate with multiple partners.

3. Paternity generally secure as limited number of other males around to compete.

Disadvantages

1. No knowledge if genes successfully passed into the next generation.

2. If highly successful, may be competing against own offspring for resources in future.

FEMALE - NO PARENTAL CARE AFTER BROODING

Advantages

1. Fecundity, so some offspring survive and reproduction.

2. Too many eggs to care for after brooding.

3. Short lifespan generally.

Disadvantage

1. Limited opportunities for breeding if batch of eggs does not survive and mother dies immediately.

2. High mortality of offspring with fecundity strategy (see table 2).

Table 9 - Advantages and disadvantages of mating and parental care strategy for male and female octopuses.

FORAGING BEHAVIOUR

Octopuses are semi-nomadic (table 10) keeping a den for a week or two before moving on (Stewart 1997).

ADVANTAGES

1. Limited cost of defending permanent territory against intruders.

2. Not wasting foraging time defending permanent territory.

3. Move before resources exhausted at site.

DISADVANTAGES

1. Do not have exclusive access to food as with permanent territory.

2. Do not have permanent place to retreat and shelter.

3. Do not have local knowledge of predators and resources when moving around regularly.

Table 10 - Advantages and disadvantages of being semi-nomadic.

During the time at a den, they go out to hunt and return home from quite a distance. This is known as Central Place Foraging (Stephen and Krebs 1986)(table 11).

In order to do this, it requires a good spatial memory using cues to navigate around the sea-bottom environment. It seems that vision is used with landmarks to navigate which allows them to make detours and overcome disruptions (by researchers) of the foraging trails (Mather and Anderson 1998).

ADVANTAGES

1. Concentrate on resources local to den before moving on to next den.

2. Reduce exposure to predators.

DISADVANTAGES

1. Increasing cost of returning as distance from den increases.

2. Dependent on good memory to find way back to den.

Table 11 - Advantages and disadvantages of Central Place Foraging.

Mather (1991) followed octopuses (Octopus vulgaris) (figure 3) in Bermuda on hunting excursions. They covered different parts of the home range each day suggesting a good memory for where they had already hunted (working memory) and where food might be found (reference memory).

(Source: Albert Kok at nl.wikipedia)

Figure 3 - Common octopus.

The octopus uses both ambush (table 12) and active hunting strategies to capture its prey of crabs, shrimps, snails, and crustaceans.

Octopuses when hunting can face camouflage from their prey. Camouflage is most effective when the animal is stationary, so octopuses have developed a strategy to startle their prey and make it move, thus becoming easier to see. They produce a dark "moving" visual display called the "passing cloud" (Packard and Sanders 1971). The octopus is stationary but their skin changes briefly along the body and arms to give the impression of movement. By the octopus remaining still, this aids its visual acuity (ie: ability to detect the moving prey).

Mather and Mather 2004) recorded 200 of 203 "passing cloud" episodes during active hunting in their observation of Octopus cyanea in an outdoor pool in Hawaii. The other three episodes took place when the octopuses were in their den.

ADVANTAGES

1. Uses little energy.

2. Avoids risk of prey fighting back (and of injury) if ambush is swift and effective.

3. Catch prey when off-guard or not expecting attack.

4. It is a strategy that can be used as well as others like active hunting.

5. Effective strategy for well-camouflaged animals.

DISADVANTAGES

1. Risk of becoming prey themselves if stationary for long periods.

2. Not effective if spotted by prey.

3. If prey are unpredictable in their habits, it means be alert at all times.

4. Risk of starvation if only strategy and prey does not come.

5. Needs high rate of success if prey infrequent or risk of starvation.

Table 12 - Advantages and disadvantages of ambush hunting for octopuses.

Mather and Mather 2004) recorded 200 of 203 "passing cloud" episodes during active hunting in their observation of Octopus cyanea in an outdoor pool in Hawaii. The other three episodes took place when the octopuses were in their den.

PREDATOR DEFENCE

The main predators of the octopus are moray eels, sea lions, and larger octopuses. Predator and prey are involved in a battle to capture versus survival, and each uses different strategies (table 13).

PREDATORS	PREY
1. Detection of prey	1. Anti-detection responses
- perceptual skills	**- hide** **- camouflage**
2. Attack prey	2. Anti-attack responses
- stealth - avoidance of certain patterns/colours	- vigilance/alarm calls - advertising of poison **- mimicry**
3. Capture of prey	3. Anti-capture responses
- group hunting - speed - specific victims	- herd - rapid acceleration
4. Consumption of prey	4. Anti-consumption responses
- begin at head - avoidance of dangerous foods - steal captured prey	- misdirect attack - concentration of toxins in vulnerable body parts - fear screams **- sacrifice arm**

(After Alcock 1993)

KEY: bold = octopus strategies.

Table 13 - Strategies by predators and prey.

The primary defence is to hide, which octopuses have a great ability to do. They hide in rocky crevices, abandoned shells, holes made in the sand, and in artificial places like discarded jars or beer bottles. "Astonishingly compressible, an octopus can ooze through an opening no bigger than one of its eyeballs" (Stewart 1997).

Secondary predators defences are also used by the octopus:

i) Firing a burst of purplish-black ink at pursuers to disorientate them.

ii) The ability to lose an arm to a predator (ie: sacrifice), and a new one grows (autotomising limb). Sacrifice is a risky strategy but may be a last resort (table 14).

ADVANTAGES

1. Strategy of last resort if cornered by predator.

2. Predator distracted by eating arm allows octopus to escape.

3. Predator may be satisfied with arm and not continue chasing octopus

DISADVANTAGE

1. Energy cost of growing new limb.

2. Cost of lack of use in foraging of that arm during its growth or reproduction if hectocotylus arm.

3. Risky strategy if used too often.

Table 14 - Advantages and disadvantages of sacrificing an arm to escape a predator.

iii) Camouflage through changing colour (table 15). Cells in the skin called chromatophores allow different pigments to come into view, and thus the animal can change colour.

Chromatophores are "pigment-containing elastic sacs of yellow, red and brown" under muscle control which means they can contract and thus change the skin colour very quickly (milliseconds). Underneath the chromatophores is a layer of other cells which reflect and refract light to give a green appearance (Mather and Mather 2004).

Octopus cyanea, for example, use a range of changes in visual appearance rather than just matching the background (Hanlon et al 1999).

iv) Dymantic display (Young 1950) - This is "threat, startle, frightening or bluff behaviour and in most cases it serves to make a predator hesitate during the close approach phase of attack" (Hanlon and Messenger 1998 p79).

Large objects cause the octopus to flatten out, coil its arm beside the body, and change colour (Burton and Burton 1976).

ADVANTAGES

1. Effective when stationary.

2. Difficult for predators' visual system to distinguish from background.

3. Involves less energy than flight.

DISADVANTAGES

1. Not as effective when octopus moving.

2. Cannot move if predator present and thus limits foraging opportunities.

3. Risky if camouflage not effective as predator close by.

Table 15 - Advantages and disadvantages of camouflage for octopuses.

v) Mimicry - Animals will mimic poisonous or distasteful species, low-value or difficult-to-catch ones (table 16).

The mimicking of poisonous species was unknown in cephalopods until Norman et al (2001) reported their observations of a small "mimic octopus" off the coast of Sulawesi, Indonesia.

Nine adults were photographed and filmed over 16 days. The mimicry including the swimming flatfish (Zebrias), and lion-fish (Pterois), raising the arms to appear like a banded sea-snake (Laticauda), sand anemones, or large jellyfish. All the animals mimicked produced toxins. This is known as Batesian mimicry (Bates 1862), where a non-toxic species mimics a toxic one.

ADVANTAGES

1. Allows the octopus to move around freely.

2. Appearing like another species that own predators do not attack.

3. Possible evidence of intelligent behaviour.

DISADVANTAGES

1. Risk from predators of the species mimicking.

2. If mimicry ineffective octopus in the open and predator sees through disguise.

3. Some predators may not be put off by apparent appearance of toxic species.

Table 16 - Advantages and disadvantages of mimicry.

Batesian mimicry is only successful with certain conditions (Lindstrom et al 2006):

- Mimics are not too common;
- Unpalatable prey must be high unprofitable for predators;
- Mimics must be accurate copies;
- Predators have alternative prey available.

Hanlon et al (2008) observed two tropical sand-flat octopus species off Indonesia for five days. two strategies of defence were used against predators - camouflage when stationary, and mimicry when moving. When camouflaged, the octopuses had body patterns and postures that resembled objects on the sandy sea-bottom, like small sponges and tube-worm tubes.

During the 500 episodes of behaviour filmed by the researchers, they found that when moving these octopuses mimicked flounders in shape, swimming actions, speed, and coloration.

This study was a naturalistic observation (table 17).

ADVANTAGES

1. Study octopus in their natural environment (high ecological validity).

2. The researchers do not interfere with the environment as in a laboratory experiment.

3. Does not involve removing the animal to the laboratory with the problems of injury for the animal, for example.

DISADVANTAGES

1. The researchers cannot control what does or does not happen during the observation.

2. Viewing conditions may not be ideal.

3. The presence of observers may alter the behaviour of the animals in the sea environment.

Table 17 - Advantages and disadvantages of the naturalistic observation method.

INTELLIGENT BEHAVIOUR

Deciding whether non-human animals are intelligent is very difficult. Before the question can be answered, it is necessary to try and define intelligence in this area. Table 18 gives a summary of the main abilities that arise when discussing animal intelligence.

1. Sense abilities beyond humans
2. Memory capacity
3. Learning including imitation/observation, problem-solving, insight, imagining (cognitive maps), forethought and planning; use of tools
4. Number and concept-handling including symbols and language
5. Self recognition, self-awareness and self-consciousness
6. Theory of mind including understanding intention, deception, and empathy
7. Culture
8. Consciousness

(After Brewer 2002)

Table 18 - Summary of abilities in animal intelligence.

Octopus intelligence has been tested in various ways including the ability to find their way in simple mazes or to distinguish squares from crosses (Stewart 1997).

"Hard and fast data about the intelligence of octopuses are not very good", but "It's extremely easy to anthropomorphise octopuses. They make eye contact with you. They respond to you. They reach toward you" (Jean Geary Boal quoted in Stewart 1997).

Octopuses have been studied in relation to three areas of intelligent behaviour - observational learning, tool use, and play.

OBSERVATIONAL LEARNING

A few cases of octopuses in zoos unscrewing jar lids after copying staff have been reported (eg: "Frida" at Hellabruna zoo, Munich; BBC News 2003).

In terms of controlled experiments of observational learning, the best known is Fiorito and Scotto (1992). They taught a group of captive common octopuses (captured in the Bay of Naples, Italy) to grab a smooth 3cm (1 inch) diameter red ball instead of a white one suspended on nylon strings using a small piece of fish as a reward and a mild 12 volt electric shock as a punishment. Training was completed when the animal made no mistakes in five consecutive trials.

Thirty octopuses were taught to choose the red ball

after an average of seventeen trials, and fourteen animals were taught to prefer the white ball (average 22 trials to learn). These were the "demonstrators".

Then untrained octopuses (n = 30) in an adjacent tank watched the correct behaviour by the "demonstrators" for four trials. This group learned quickly to grab the red ball (within five trials). Of 150 total trials with the red ball, this was chosen correctly 129 times (86%) and 70% correct from the seventy trials with the white ball. This compares to 51% success rate by "demonstrators" after five trials.

This laboratory experiment (table 19) was the first case of observational learning reported in an invertebrate (Stewart 1997).

ADVANTAGES

1. Researchers can control variables in a way not possible in the natural environment.

2. It is possible to isolate cause and effect in the experiment.

3. Standardised procedures allow replication.

DISADVANTAGES

1. It is an artificial environment (low ecological validity).

2. The octopuses may behaviour differently because it is not their natural environment.

3. The ethics and practical problems of capturing the animals and then studying them. For example, octopuses are captured by placing a large plastic bag over them and sealing it with water inside (Mather and Anderson 1993).

Table 19 - Advantages and disadvantages of the laboratory experiment method to study octopuses.

The research by Fiorito and Scotto (1992) has been criticised in a number of ways:

i) Untrained octopuses have a preference for red balls any way. Untrained animals tested by Fiorito and Scotto preferred the red ball 58 times and the white ball sixteen times in 90 trials.

ii) Fiorito and Scotto described their teaching of the "demonstrator" octopuses as using classical conditioning, but, technically, it was operant conditioning (Biederman and Davey 1993).

iii) The choice of targets should have been more than two to avoid the "observer" octopuses being "inadvertently

'directed'" to the correct ball (Biederman and Davey 1993).

iv) The research was an experiment in a laboratory tank and using situations not encountered in the octopuses' natural environment.

v) The effect of the capture and captivity on the animals. Mather and Anderson (1998) reported that laboratory studies with Octopus rubescens are difficult because they do not get used to the tanks (swimming in panicked circles during a month of testing).

TOOL USE

Tool use involves modifying, carrying or manipulating an item that is external to the animal and then using it to change the environment in some way (Beck 1980).

Mather (1994) noted Octopus vulgaris in Bermuda using rocks as a wall to the opening of their hole in the sand (den). These animals were observed to pick up small rocks and place them in front of the entrance with a pattern of the bigger the hole, the more rocks collected.

Mather and Anderson (1998) argued that octopuses use water from their water-filled mantle cavity as a tool. For example, the jet of water is used to clear out sand and small rocks from its den, "much as we would sweep with a broom".

PLAY

Wohlwill (1984) defined play as "spontaneous activity, not directed at some externally imposed goal or serving some ulterior purpose..".

Mather and Anderson (1998) reported evidence of play in the Giant Pacific octopus at the Seattle Aquarium. The researchers placed a floating pill bottle in the tank in ten trials over five days. Initially, the octopuses grabbed it and brought it to the mouth as food. Later, two of the octopuses jetted water at the "toy" and made the bottle circle the tank for over ten minutes. "If a human were doing this, someone would say we were bouncing a ball" (Mather and Anderson 1998).

CONCLUSIONS

It is probably the wrong question to ask if animals are intelligent. Most importantly, animals evolved the

abilities needed to survive in their environments. In some cases, it is limited compared to others. Brewer (2002) argued that intelligence is made up of different separate abilities ("intelligences"), but these abilities share common strands. Only in humans do all these separate abilities produce "Intelligence". Which "intelligences" exist for animals depend upon the demands of their environment.

PERSONALITY

Mather and Anderson (1993) described individual differences between forty-four adult Octopus rubescens studied that could be called "personality". The animals studied were captured off Seattle, USA.

The octopuses' responses were tested in three ways and nineteen behaviours were recorded:

i) Alerting - the researcher stood above the tank and looked down at the animal. Seven different responses were recorded including skin colour changes ("colour change") and moves away from observer ("shrink");

ii) Threat - the octopuses were touched briefly with a brush. The seven different responses included "squirt" (jets water at the brush), "ink" (squirts ink) or "grasp" (grabs brush);

iii) Feeding - prey were dropped into the tank. There were five different responses noted.

The different responses in the three tests were submitted to factor analysis to look for clusters of behaviours. Three dimensions of "personality" were found: Activity (active-inactive), Reactivity (anxious-calm), and Avoidance (avoiding-bold). Table 20 shows how each "personality" responded on the three tests.

	ALERTING	THREAT	FEEDING
ACTIVITY	Stay in den	Grasping brush	Alert
REACTIVITY	Shrink	Squirt water or ink, but does	Alert
AVOIDANCE	Colour change	Stay in den	Stay in den

Table 20 - "Personality" types and behaviours among octopuses.

Mather and Anderson (1993) felt that the individual differences they had observed were more than just

situation-specific, and were longer lasting, thus the label "personality".

The suggestion that non-human animals have "personality is controversial, and there are arguments for and against such an idea (table 21).

ARGUMENTS FOR

1. Individual differences have evolutionary benefits, particularly in response to the changing undersea environment. Octopuses have many offspring which would allow for genetic variation and mutation, and individual differences to develop.

2. Octopuses show learning, and such changes in behaviour will produce variability between individuals.

3. Differences in the central nervous system can be seen as the origin of individual differences, and octopuses have sophisticated central nervous systems for invertebrates. In relation to human personality, Eysenck and Rachman (1965) linked introvert-extravert to differences in the recticular activating system (RAS) in the brain.

4. Individual differences have been reported in various other species; eg: cats (Feaver et al 1986), and sticklebacks (Huntingford 1976).

ARGUMENTS AGAINST

1. The risk of anthropomorphism. This is the attribution of human qualities to non-human animals. Individuals who work with animals become attached to them and can want them to be more than they are; eg: aquarium volunteers give octopuses names and ascribe personality types to them (Mather and Anderson 1993).

2. "Personality" is "a word loaded by its use on humans", and researchers at the 1991 International Ethological Congress workshop on individual differences in animal behaviour preferred the term "temperament" (Mather and Anderson 1993). However, this term also has connotations in relation to its use with human babies.

3. Are these individual differences learned from experience as the animal grows or something they are born with? Human personality theories tend to see the latter and argue for a biological origin (eg: Eysenck and Rachman 1965).

4. The research of Mather and Anderson is based in the laboratory after the octopuses had been captured, and it is not their natural environment. Thus their behaviour may not have been typical.

Table 21 - Main arguments for and against the existence of "personality" in octopuses.

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