- Chemical control stages of control Relatively easy to control Varroa with one autumn pesticide application, Very difficult to control (Varroa in the feral population) up to 50% loss of colonies, Became easier to treat (feral populations dead) More difficult to control – pesticide resistance. Control by monitoring, comb trapping, forcing an artificial swarm into a clean hive, drone blood collecting.
- Biological control Two insect pathogenic fungi being trialled Metarhizium anisopilae Beauveria bassiana (patented in US July 2012). Must be able to cope with – High temperature 32–37oC – Low relative humidity 40–50%.
- Bee resistance not a problem for A. Cerana A. cerana grooms better than A. Mellifera, A. cerana bites and kills mites, A. cerana can detect mites, uncap brood cells and kill them, A. cerana pupae spend less time in cells less time for mites to develop.

## Week 2 - Sugar Cane

- Sugar 4 types of sugar jaggery, granulated, spun and rock. Production mainly in the Mediterranean region. Modern sugar industry - Global expansion of colonial powers creates economic opportunity for tropical crops (tea, sugar, coffee). Characteristics of sugar cane make plantation scale production essential: with need for large labour force, The addictive, stimulant properties of sugar make possible the *creation* of demand in working classes of (some) European countries. Recent realignment of sugar cane towards renewable energy production.
- Slaves Peculiarities of the sugar cane plant, Range not frost hardy likes to be with Propagation – vegetative – takes time, Nutrition – very heavy feeder. Slish on burn gave only temporary good yields, Perennial; needs feeding for ratoon cross. Pirsty – irrigation or consistent rain supply for best growth. All this means are cane is a plantation crop. Required huge labour input in very hard conditions, OS of abour too great; indentured labour didn't work, So slaves were used a ther thangular trade' - slaves to are rice -> sugar/tobacco/cotton to europe -> textiles (num and goods to africa -> slave) etc...
- The plant Sacch cam officinarum Kitk arm plantae, Phylum magnoliophyta, class licos da, order - poales, fanily - orace ac. Attributes - stem storage of sucrose, rapid perennial growth - C4 Photosynthesis. Breeding - noble canes of new guinea and polynesia selected for high sugar content of stems, - offers evolutionary advantage. Stem storage of sucrose is unusual - most store starch instead, Sucrose storage requires specialized accumulation apparatus - Internodes of stem, Vacuoles of parenchyma cells, Pathway – leaf (sucrose) – phloem – apoplast – cytoplasm (as glucose/fructose) – vacuole (sucrosephosphate), Energy requiring.



- C4 Photosynthesis Plants are inefficient at harvesting the sun's energy. Sugar cane 1% of sunlight used; 1/5<sup>th</sup> of this converted to dry matter. Whopping dry matter accumulator, even so - 80 tonnes/ha/year cane stalks (cf. 25 tonnes/ha/year wheat in UK) C4 photosynthesis optimizes dry matter production in high light/high temperature environment of tropics. C4 more efficient (in high light/high temperature environment) than C3 when atmospheric CO<sub>2</sub> is low, C4 is relatively recent (50 million years ago) and has evolved many times in different plant families. Becomes really prominent 5-7 million years ago when CO<sub>2</sub> declined to current level (350 ul/l).
- Production see picture.
- Bioethanol from sugar see picture.



- Moths lepidoptera, cocoons made of silk, silk used by larvae for ballooning. Endopterygpte insects - complete metamorphosis. Caterpillers - prolegs on abdominal segments, with crotchets. Larval mouthparts - well developed silk gland - modified salivary gland through labium, 3 segmented antennae, 6 ocelli. Silkworm - Bombyx mori.
- Sericulture production of cocoons for silk reeling, production of eggs, food plant production.
- Rearing of caterpillars Keep them warm when small, Make sure that they are ventilated, Observe when they moult, do not disturb them, Place new food on top of the larvae, then remove the old food, Do not keep too many in one container, Do not touch the larvae, Check the larvae and immediately remove any sick ones.
- Egg production Univoltine 1 generation per year Eggs hibernate autumn/winter, Bivoltine 2nd generation in autumn, Multivoltine – Tropical, poorer quality silk.
- Silkworm domestication Probably one domestication event Lost 33–50% nucleotide diversity relative to wild silkwormm, Selected for: - Cocoon size, growth rate, digestion efficiency – Tolerance of humans, crowding, selected against: – Flight, predators, disease avoidance

- Sea lice on salmonida only, fish can have up to 200 lice, more than 50 will cause problems, cost £25m to contain.
- Sea louse free living planktonic nauplius stage, released onto water by female. Free swimming infectiously copeodid stage, feed on skin - open wounds, osmoregulatory regulator, respiration impaired. Lay 100-1000 eggs, can survive winter.
- Treatment bathe fish in chemicals, organophosphates, hydrogen, pyrethroids. Add antibiotics to salmon diets. Treatment onsite before stocking, decreased net fouling. Fallowing - wait 2-3months before restocking, vaccines, cleaner fish.

## <u>Week 9 - Rabbit</u>

- The rabbit oryctolagus cuniculus, order lagomorpha, family leporidae. Lepus Mountain/common hare.
- Breeding Breeding season coincides with availability of good food (Spring in UK), At approach of breeding season form into social groups, up to seven adults, Establish a territory, each member has an overlapping home range, Males have linear dominance hierarchy, females have some hierarchy. Doe makes nest in a short blind tunnel (a stop), closes tunnel mouth when absent, Ovulation induced by coitius, Bucks wait for does at mouth of nesting burrow and mate when they emerge after dropping litter a doe can be both pregnant and lactating, Does generally monogamous. Gestation about 30 days, 3–7 in a litter, Does ready to breed in 6–10 months, Can live for 8–9 years, Resorbtion of embryos under stress. Rate of incluses 12x annual increase, with mortality is around 8x increase.
- Domestication Today 1–1.6 million pet rabbits and 40 million with abbits in UK, Domesticated in last 1500 years from single origin is sorthear france, founding population of less than 1200 – Probably from a decree by rob. Gregory the Great that new born rabbits were not meat and could be eaten during Lent, 200 breeds to ray, most arose in last 200 years, Domestic rabbits have lost 17-44% of their genetic diversity, more than in other domesticated mammals
- Hab bits roch: UK Introduce in CU (by Normans, just after conquest, probably from France, Kupt in warrens No warrens mentioned in Domesday Book, Mentioned first on islands 12th century (Scilly Isles 1176). Inland by 13th century: Guildford 1241. Warrens rabbits caught from here through nets and traps, helps catch them for meat and fur.
- History The rabbit becomes a game animal 1765: Anyone caught stealing rabbits at night could be transported for 7 years 1828: Night Poaching Act 1831: Game Act rabbits could be sold 1880 Ground Game Act: tenants given right to kill rabbits on their land, landowners set up warrens to breed them for sport. Decline in poaching, From 1880 an increased amount of rabbit trapping, In 1934 over 50 million skins and fur sold for hatting in UK, and 30 million sold overseas, Trapping increased rabbit numbers! Does preserved for next season More bucks trapped more food for offspring Traps also caught predators, In 18th and 19th century parks rabbits became fashionable, In late 18th century, hunting became more popular: pheasants, partridges need to be protected from vermin, Active preservation and encouragement of foxes rabbits introduced as food. 1917: rabbit order in the Defence of the Realm Act, rescinded 1921, 1920: Forestry Act, 1938: Destructive Animals Act, 1939: Prevention of Damage by Rabbits Act Landowners could be made to control rabbits, 1939: Rabbits Order under Defence of the Realm Act Officials could enter and take rabbits from any land anytime anyhow, Late 1930s: 50 million wild rabbits, Early 1950s: 100 million, 1954: Pests Act: Rabbit Clearance Areas established.
- Predators of rabbits foxes, badgers, stoats, weasels, polecats, cats, rates, buzzards.

- Genus canis wolves and dogs, canis lupus wolf. Coyote, c.aureus jackal, d.familiaris domestic dog. Many members of the genus can interbreed successfully.
- Canis lupus Most widely distributed of all land mammals, One of the most adaptable, Inhabits all vegetation types of N hemisphere, Preys on all the large mammals living there.
- Evolution Wolf reinvaded N America 700,000 years ago, Earliest wolf possibly represented by Red Wolf, Evolved into Canis lupus, Several extinct species, including very large Dire Wolf, C. Dirus.
- Wolf generalist carnivore Flexible and opportunistic, scavenger, Relatively short gut, Teeth & skull: – Makes numerous shallow bites – Bites without precision, can dislocate lower jaw. Teeth - molars - crushing, canines - slash at hide and muscle, incisors - for grasping and holding prey.
- Prey Mainly large ungulates, deer, elk, moose if available, with loss of these prey turns to livestock. Hunting - Boldness, speed and endurance, Most prey are potentially damaging to the wolf. Stalking - prey, alpha in lead, encounter, rush to get larger animal moving, chase to single animal out, Although the whole adult pack may participate in the chase, killing is usually done by a couple of wolves, smaller animals also taken
- Wolf packs Alpha male and female Usually the only pair that breed in the pack, Offspring from a number of years, Uncles and aunts – Often with babysitting duties, Adopted wolves – Sometimes from other packs, Pack size 2–42. Winter: hunting in packs, may move long distances Mating: Feb–March Cubs born April–May Pack is sedentary in home range in summer. Complicated dominance hierarchies maintained within pack, prevents serious fighting. Dominant - tail raised, head erect. Submissive, tail between legs, head lowered, ears back. Offspring remain with pack for 10–54 months and then disperse, Must find a mule and a territory, If no territories – Wait until a breeding position opens up in the party Become an extra breeder in the pack, Carve out a new territory, Usurp an actic preceder, Long distance dispersal: 'lone wolf'. Each pack has a territory, the size Spece depends on food availability.
- Territories Territories are defended from the ge woives, those from other packs or 'lone
- wolves'. Wolves usually die eithes from stal vation or fights with other wolves. Wolves and humans Originally positive: provided pill and domesticated Positive in Celtic • and Greek myth (Park Became a threat with Jonnestication of livestock, Changed with Cinist a By - Wolf a symbol of point, cunning, deceit, wantonness – Werewolves: Human/wolf, Steppenwoll – Symbolic wolf – a reflection of the human condition.
- Wolves and dogs Generally accepted that dogs evolved from wolves alone. Two theories -Dogs arose from wolves in SE Asia, Dogs arose from a now extinct line of wolves in Europe, 19– 32,000 years ago
- Domestication Reduction in skull size, Shortening of muzzle, Relatively broader palate, Steeper forehead, More crowded teeth, Like a young wolf - Paedomorphosis
- Wolves in north America many species. US wolf removal Started with first import of livestock, 1609, By 1700 extinct in New England, 1750: better traps and strychnine, 1870: disappearance of buffalo, more wolf attacks on livestock. Division of Predator and Rodent Control (PARC) 1915 – To eliminate all wolves on Federal land – 1930: wolf disappeared from most of USA, 1967: grey wolf placed on US endangered species list.
- Great lakes By 1965 wolves removed from 97% of their former range in USA 700 left in NE Minnesota • 1978: recovery plan – Prevent hunting – Protect habitat. Isle royale - ice bridge allowed wolves to migrate, but numbers now declining and may go extinct, very interbred. Wisconsin - extinct in 1960s, in 1970s wolves recolonized from Minnesota. Michigan - wolves recolonized from minnesota and wisconsin, increase from 6 to 360 in last 30 years.
- Yellowstone Eradication campaign, 1905: bill passed to mandate infection of wolves with mange, Strychnine, Most wolves disappeared 1920s, Last 2 killed in Yellowstone 1924, Last one killed 1943. 1970s: first plans to reintroduce wolves, Nez Perce tribe volunteered to be local managers, First wolves introduced 1995. Wolves have become used to humans, Wolf