Adequate earthworms can double pasture production within months.

The two most important earthworms in pastures are Apporectodea Caliginosa and Lumbricus Terrestris. They did not originate in New Zealand, but are well established now and are in vast numbers in correctly limed soils. The more costly lime pellets should not be bought because they are useless for earthworms, and don't mix in with soil or get moved down in soils. The dust loss they claim doesn't leave your farm, and the wider spread doesn't take added elements with them. Caliginosa earthworms will establish only where there is animal manure from grazing animals, without which they disappear. They also need fine agricultural lime regularly to sweeten New Zealand's wet acid soils. The large deep burrowing Terrestris tolerate a wider variety of soils and continuous cropping, which others don't. There are also Foetida compost or Tiger earthworms which were named because of their stripes. They excel in compost, but live for only about six months in high organic matter, damp conditions.

Dairying removes about 0.8 tonnes/ha per annum, and beef about three quarters that.

On calcium deficient soils, which is all of New Zealand, two to four applications of five tonnes per hectare (3 tons/acre) increases the calcium (Ca) level to 0.9% of Ca in ryegrass leaves and stems, and increase earthworm numbers, provided earthworms were there to start with. Ryegrass is in all NZ and gives accurate consistent Ca figures.

See the last page about the canabalistic earthworms that eat others. They are eating good earthworms in UK and Ireland, but are not a problem in NZ. Don't bring polluted soil onto your farm and keep in touch with your neighbours, to ensure that you don't get these canabalistic earthworms which could come from them. Overseas they are called New Zealand worms as if they originated here, but they are in only very few areas here.

Charles Darwin in 1881 wrote, "It may be doubted whether anything else has played such an important part in the development of the world's soils as have earthworms." He pointed out that humans would not have developed and hardly be able to survive on earth if it were not for earthworms turning the forest leaves and pastures' dead leaves into organic topsoils.

Julius Caesar identified earthworms as beneficial and declared them protected. It is a pity that so many researchers and farmers today, don't seem to know what the above knew so long ago.

New Zealand's indigenous forest earthworms did little of any use, so Caliginosa, Foetida and Terrestris were imported 150 years ago, and now cover most of New Zealand.

Earthworms deepen soils, which give the plant roots more depth to use the nutrients before they leach and pollute the subterranean water. Read the chapter on Pollution.

Earthworms also improve soil structure, eliminate facial eczema completely (I discovered and demonstrated this in 1958 on our Piako Road farm and on many more farms, but the 'establishment' won't accept this because none of them can claim it or make any money out of it) by taking dead surface vegetation (thatch) into the soil, to increase soil fertility, humus, carbon and earthworm numbers. Fertiliser companies sponsor most of the establishments giving them millions of dollars annually. LimePlus that is needed to increase earthworms to eliminate Facial Eczema, reduces fertiliser requirements, which fertiliser companies don't like, so discourage lime.

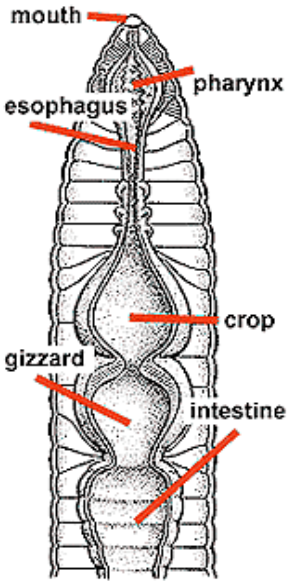
E. Lee, Soil Bureau, DSIR, Wellington, wrote in 2007, "The study of the role of earthworms in New Zealand soils is a subject which has received little attention from biologists. The great number of earthworms frequently found in the soil is sufficient to indicate that their activities must have a marked influence on the soil in which they live. However, in New Zealand there has been a lack of exploratory work about groups of invertebrate animals, and earthworms are among these groups."

This chapter of 24 pages on earthworms could be the most complete and up-to-date earthworm document available.

Earthworms are soil living animals that consume and improve soil, consume animal manure, dead plants and dead vegetation, and excrete them in soils or in casts above the ground. The analysis of castings shows that both phosphorus and sulphur content are higher than in the surrounding soil. Each day earthworms consume up to a third of their weight of soil, dead vegetation, dead insects, insect eggs, dead animals and manure, which is better than fly maggots doing so and becoming flies. Earthworms have no teeth, but possess a very strong mouth muscle and a gizzard, like birds have.

Earthworm cutaway

From www.marthamine.co.nz/schools/worms_sch.html



Earthworms don't have teeth or eyes, or a nose or lungs, but breathe through their skin, that is light and and touch sensitive and should always be moist. Their gizzard needs fine sand and agricultural lime to help grind up what they eat. They have a very strong acid which aids digestion. They respire through their skin, and therefore require moist conditions to prevent drying out. The skin mucus enables the passage of dissolved oxygen into their bloodstream. Without adequate calcium from agricultural lime they can't make mucus, so have dry skins.

Earthworms have both male and female sexual organs (hermaphodrites), but most still require a mate for breeding.

Statistics

There are about 3,000 species of earthworms in the world, but very few are common in any one area. Some live for nine years, some (Foetida compost earthworm) only six months. Numbers are highest in high organic, temperate soils, getting animal manure from grazing animals. Rotary cultivation systems halve earthworm numbers, compared with no-till or chisel ploughing. Urea and some weed sprays halve numbers after each application. LimePlus, a term (not registered) for agricultural lime with serpentine and deficient elements, increase earthworm numbers. Superphosphate can help them when P is low, but reactive phosphates like Gafsa and Sechura help them a lot more.

Conditions they like

Drainage must be adequate so that earthworms can go deep enough and not be drowned, or frozen if too near the surface in winter. The pH should be at least 6.2 (5.9 in peat or high organic soils), with regular dressings of LimePlus to prevent the top centimetre from becoming acid from dead vegetation (surface thatch). If lime is added to bring the pH up to 6, the earthworms will multiply faster and grow bigger. They also adapt to the conditions in which they develop, for example cattle manure, sheep manure (or both), lawn clippings with soil, and a soil base for Caliginosa earthworms.

In very dry weather some types will go deep and destivate, which is curling up into a knot and sleeping until rain comes. The touched one is waking. Adequate lime in soils keeps them more moist, so even in long dry periods as in May 2010, when not much rain had fallen for three months, earthworms continued working on Barry Brunton's beef farm which had 8.5 tonnes per hectare over the previous two years, needed because, guided by a fertiliser company, it had not had any lime for three decades.

Soil can become wet on top from a little rain, but the destivating earthworms remain so, until moisture reaches them. Terrestris numbers didn't reduce because they go metres deep and rise again for food even if dry. It is important to also have Terrestris and Longa in pastures. Longa go deeper than Caliginosa. Caliginosa and Foetida make cocoons that don't hatch until moist enough. They are called cocoons because each one hatches one or more babies (without hormone treatment!). As the sheath slides forward, it picks up ova from the earthworm's ovaries and sperm that had been transferred to the worm from another worm during mating. The sheath slides over the worm's head and the ends seal to form the cocoon. The cocoon is originally soft and yellow, then becomes harder, light brown in colour, two to four mm in diameter and very resistant to drying and damage. In dry conditions a cocoon is normally several cm deep in the soil and can lie dormant until moisture reaches it.

A reasonable calcium level is required. If lacking, the application of lime makes earthworms multiply rapidly. The cocoon here has been exposed and pointed to with a piece of 2.5 mm (12.5 gauge) wire. A partly exposed Foetida earthworm is on the left.

Conditions they dislike

Earthworms dislike dry, sodden, hot, cold, acid, toxins, urea, old stored animal manure which

becomes high in ammonia, mineral deficiencies, loose soil (They think rodents or birds are digging forthem, so they go deeper.) and in particular a lack of calcium. Drenches and pour-ons against internal parasites have been found my many farmers in Australia to decrease earthworm and dung beetle numbers on their farms. It is bad farming to treat all animals for worms because it encourages resistance. Just treat those decided by dung tests and visual symptoms of the animal. In New Zealand most of the animals drenched for worms are just low in selenium or have excess manganese. See the photos in the Beef Profiting chapter. All types of farmers should read it.

Firstly get your calcium and mineral balances right in the soils, pastures and animals. Some may say that if minerals are right in the soil, then surely they should be in the pasture. Yes, but not if the pasture is only one grass, which will be worse if it is shallow rooting ryegrass, mostly because of low calcium causing high aluminium. See Animal Health > Parasites.

Soil sticking to earthworms as shown here is a common sight in many NZ soils lacking lime which causes a lack of mucus on their skin and restricts their breathing which is done through their skin. The skin mucous allows earthworms to slide through the soil more easily and lines the holes of those reusing their holes such as the deep digging Terrestris.

Excess urea

Earthworms will not stay in lawn clippings from lawns that have had too much urea applied, which can cause high nitrate levels. I applied 60 kg per ha of urea to our lawn in 1980 to reduce earthworm numbers because their casts stuck to our shoes and came into the house. We put the clippings into our garden compost heap as usual. The earthworms that had done a great job converting lawn clippings into compost for years disappeared and a slimy smelling mess developed which attracted flies. We had to bury the whole lot and start again. The earthworms returned.

Old animal manure

Plants, soils, earthworms and town neighbours don't like animal manure that has been stored for a week or longer without added agricultural lime to stop it going acid and smelling. When spread, smelly stored animal manure can kill earthworms and create a skin on the surface of soils, whereas fresh animal manure doesn't.

In Switzerland in 1982 their department of agriculture asked me to come to their farm where earthworms had come to the surface and died and they didn't know why. They had spread six month old cow yard manure (effluent) stored in silos without lime on to pasture.

If you have to spread old effluent, do so just before, or in rain, and spread it thinly over a wide area rather than thickly on a small area, unless about to cultivate it in. With all the above, if the calcium levels of the soil are not optimum, spread agricultural lime to help decompose the manure, increase earthworm numbers to help decompose it, and to reduce ammonia release which attracts flies.

Better still, add agricultural lime to it before storing it in heaps, tanks, silos (common in Europe), etc. Heaps of organic matter with LimePlus mixed in will encourage earthworms to it, to eat it, multiply in it, all of which can reduce the volume and improve it by making it into a surperb black plant food. Some sand (mineral soil containing minerals we don't even know about) mixed in it, will improve it. Troughs with Solminix water running over, attracts earthworms which climb up to consume it. I've not seen this with other soluble mineral mixes, which mostly have oxides which are fertilisers, whereas Solminix has all sulphate forms.

Glyphosate or Roundup

I'm certainly not a fan of them and would ban them, have never used any one of them, except for a few trials, but am a fan of honesty. I had read in an organic article that glyphosate (Roundup, etc.) discourages earthworms, but I had seen no evidence of it, so did some trials on our lawn. Large Terrestris and Caliginosa pasture earthworms continued to make casts and were just as active under sprayed areas as non-sprayed areas half a metre away. Small foetida (Tiger) compost earthworms were not present so I don't know about them. Glyphosate is seldom sprayed more than once to kill pasture for

cropping, so while I don't know about several sprayings, which would normally be years or at least many months apart, it didn't apply again after one spraying. Years ago I asked a person who wrote that glyphosate killed earthworms to do a trial and inform me. He has not replied, so I assume he found that it didn't, and was just stirring up to look good for the "green" group, which is an important movement, but should be very careful to keep to honesty and to proven information.

I have found that not many fertilisers (In this eBook, fertiliser is those other than nitrogen, that is called "nitrogen") applied at reasonable rates inhibit earthworms, in fact if an element is low and is applied correctly (not in excess), even if acid treated P like Superphosphate, it will increase earthworms and soil organisms. Good reactive phosphate will increase them faster, and applying trace elements that are lacking will increase them even faster. An excess of anything will discourage them.

Ants

These eat some grass that animals could, some dead grass that earthworms would eat. Earthworms do a better job of mixing it into the soil and spreading it around more, while that from ants is concentrated in smaller areas.

Some ants like building nests in buildings and need repeated control methods by rotating Neverwrong, boron and copper, all in honey which attracts the ants to their death.

Endophyte

To my knowledge, endophyte in ryegrasses, toxic to some pests, doesn't reduce earthworm numbers, presumably because they are not eating growing green ryegrasses.

Minerals

Earthworms are healthier and more prolific where the necessary minerals and trace elements needed by the grazing animals are applied with lime and/or fertilisers. Minerals needed for earthworms can be the mineral mixes fed to animals. Solminix is the best because all are in the non-toxic sulphate forms. See Feeding Minerals & Supplements > Solminix.

We spread a heaped tablespoon of a reactive phosphate Phosphorus Nutrient Planner spreadsheet (no artificial fertilisers) complete fertiliser over ours (two square metres) once a month and a heaped tablespoon of Solminix two weeks later.

How I first learned how much earthworms needed good mineral supplements, was when a water trough, that had Solminix, a soluble mineral mix I developed, overflowed for a few days. Earthworms gathered thickly in the soil at the overflow point and were trying to climb up the side of the trough. The soil was moist from rain, so that is not what they needed. Then to convince myself I spread half a heaped tablespoon of Solminix over half our compost bin. Within a few days there were a lot more earthworms where it had been spread. The grass used in the compost was from our lawn that had been fertilised with correct minerals based on a pasture analysis, so was not severely mineral deficient, but, as with grazing animals, more minerals are needed than can be supplied by pastures.

Earthworm requirements

Earthworms don't like hard, compact or acid superphosphate fertilised soils, but do like ample lime. It is useless spreading earthworms on dry poorly farmed soils. Drainage must be adequate so that earthworms are not drowned or frozen solid in winter. Regular dressings of finely ground agricultural lime are needed to maintain calcium levels, and to prevent the surface from becoming acid with dead vegetation. LimePlus should be treated both as an earthworm food and as a soil and effluent conditioner and a fertiliser, so be applied to keep ryegrass levels at 0.9% calcium. A plant analysis will show this, a soil or pH measurement will not give accurate Ca figures. Soils must have adequate organic matter, good pasture cover and all the minerals required by grazing animals. Pasture tissue testing, and then applying a balanced lime and/or a fertiliser mix, both with any deficient trace elements, are essential.

New Zealand's high producing grazed dairy farms send about 800 kg per hectare of 98% calcium carbonate lime away in milk per annum. Selling silage or hay removes 30 to 60 kg per ha of calcium.

LimePlus is the main factor that makes earthworms increase, and makes vegetation decompose without smells or flies. Adding deficient minerals, increase their activity.

Soil microbes

A further advantage of farming to encourage earthworms is that the same conditions encourage healthy animals and soil organisms, fungi and bacteria. Earthworms do a great job, but soil microbes decompose even more dead organic matter into humus than earthworms - provided the soil is live and healthy. There are hundreds of different soil microbes and billions can fit in a teaspoon of good soil.

Increased Moisture

The moisture holding ability of soils with ample earthworms can increase by 17%. To maintain a high density of earthworms in a pasture requires an optimum animal stocking rate to provide animal manure for the worms. Most earthworms (not Terrestris) like animal manure and some will stay under or near it until all is consumed, then they move to more.

Compost spread on pastures improves the soil's moisture holding ability. Spread it as soon as possible after grazing, and preferably just before rain.

Moisture control with plastic over compost is critical for making high quality compost. A cover allow you to regulate the moisture in your pile by keeping moisture in during dry weather and keeping excess moisture out during wet periods.

Earthworm numbers per hectare

Information collected shows that ten million earthworms per hectare which is 40 per spade spit in damp pasture soil, consume and excrete 60,000 kg of soil per hectare per year, aerating the top soil, making it freer draining and deeper. Earthworms can produce up to 30,000 kg of castings per ha per annum and lay about 30 cocoons a year. They can increase phosphorus, sulphur and potassium levels by 14 kg per ha per annum.

They encourage the deeper rooting of plants, pasture improvement with less fertiliser, less mechanical subsoiling, less facial eczema and less pasture renovation. Deep rooting of pastures and all plants reduces N and P leaching (waste) to underground water (pollution). If you have fewer than five earthworms per spade spit, you could benefit from improving things, but if over 20 (500 per m2) you are getting there. Having 40 is excellent and can occur when soils are moist (not during prolonged dry periods) and when about 3 cattle, or 25 sheep or their equivalents, are grazing each hectare (1.2 cattle or 10 sheep per acre). These numbers can only be achieved in temperate areas after optimum agricultural lime, fertilisers and trace elements are applied as required. They can then provide the phosphorus, sulphur and potassium levels required by some soils for maintenance. Earthworm are concentrated fertilisers, being composed of 0.86% potassium, 0.85% phosphorus and 0.82% sulphur, so that when the earthworms die they supply these to the soil. Each year they can incorporate up to 80 kg per ha of nitrogen (N) (equals 160 kg or urea), 14 of phosphorus (P), 8 potassium (K) per hectare per annum and some sulphur (S) in plant available forms. These levels are as much as is required by some soils for maintenance.

Earthworms need minerals

The following shows that earthworms need minerals. When walking around the peat dairy farm of Elsa Lye, checking pastures, soils and soil life, I commented that her few earthworms looked sick from a lack of trace elements that are lacking in peat. She questioned my statement. In her garden around her house, I noticed a heap where she threw the tree leaves, so I dug under them and found a lot more earthworms per spade spit. They were extremely healthy because of the minerals provided in the leaves from the deep rooting trees bringing them up. I took a pasture sample from an average area and worked out a fertiliser mix with trace elements. Her herd of dairy cows improved in production and health, as did her soils, pastures and earthworm numbers and health.

Many peat farms aim to cultivate and regrass 10% of the farm each year. The correct earthworms, regular liming and non-acid reactive phosphate fertilisers, with trace elements, extend the life of peat pastures before resowing is necessary, saving considerable expense and increasing pasture production. This is particularly important on peat that some who follow 60 year old and wrong science, and fertiliser companies who don’t want anyone buying lime, say that peat won’t benefit from applying lime on the surface. Peats that are live (with earthworms and soil bacteria) do absorb lime, while peat soils that are dead from a lack of LimePlus don’t.

A heaped tablespoon of reactive phosphate (RP) with trace elements on each square metre 15 cm (6 inch) deep of compost will also encourage earthworms, as will the same amount of Solminix Feedtech

minerals from NZ DeLaval stores. Trials that I did showed that the earthworms moved to the areas where Solminix was spread at a heaped tablespoon per m2.

Soils fed with complete correct fertilisers have more and healthier earthworms than deficient soils. Mineral-sufficient earthworms are full and round, agile and slimy without soil sticking to them. Mineral-deficient ones are dry, sluggish and have particles of soil stuck to them.

These Calignosa earthworms are big, slimy, healthy, strong and active, because the Waikato dairy farmer fed his cows Solminix through a dispenser some of which goes out of the animal in their dung. Balanced minerals in soils are the saviour of soils, earthworms, animals and people.

Earthworms, especially Calignosas, need good soil to do well. Good well fed soils and animal manure will increase the Calignosas. We use sheep pellets in our garden. A lot of vegetation (lawn clippings and prunings) with LimePlus and little soil, will increase Foetida (Tiger) compost earthworms.

Our Second farm

In 1984 we swapped our 87 ha dairy farm with a good long term 50% sharemilker for a run-down 107 hectare (264 acre) consolidated peat farm on Greenhill Road, Puketaha, near Hamilton's Northeast boundary. It had been growing maize for a few years so had no pasture earthworms (Allobophora or Aporrectodea Caliginosa), only the 10 to 30 cm long Lumbricus Terrestris earthworms (USA Night Crawlers or Dew worms) that burrow the deepest (down to 1.5 m depending on soil type and water level) so they can get away from sprays and chemicals used in non-organic maize growing. We converted it back to pasture and reared and grazed 160 calves each year, grazed 100 beef, 200 heifers and 150 dry cows in winter.

Sources of earthworms

I knew from what I'd seen and read that earthworms could increase pasture growth. AgResearch in Palmerston North in the 70's achieved increases in pasture growth of 25% from areas with ten million earthworms per hectare (40 per spade spit), compared with areas that had none. So we started breeding them in our city garden in Hamilton and taking them to our farm. After a while I wondered if the worms that happened to be in our garden were the best. I remembered reading about John Stemmer's earthworms in Motueka, South Island, so phoned him. He has now retired and doesn’t breed or sell them. He assured me that his which were originally from North America where Calignosas originated so were likely to be more active than those we had, so I bought a thousand of his Pasture Calignosa earthworms. On arrival, as a comparative trial, I put 100 of his and 100 of ours (both mostly Caliginosa) in separate 20 litre (5.3 US gallon) drums of soil covered by turf. Each day I sprinkled a few old lawn clippings on the surface of the drums. Without a doubt his were twice as active at taking the dead grass down, making casts and breaking up soil. I was amazed. Previously I had thought that apart from the different varieties in pasture soils, that all earthworms were the same. We then bred them. When buying earthworms, stipulate that you want pasture earthworms that should be mostly Caliginosa, with some Longa which are longer and wriggle must faster.

If you get some from an organic farm's pasture-soil they are likely to be Caliginosa and Longa. Organic farms can have twice the number per spade spit. If from under manure pats in moist areas, they could also be Rubellus and/or Foetida, which are not true pasture earthworms, but compost ones, also called Tiger worms because of their stronger stripes.

Spreading earthworms

There is no need to use the often-described system of bringing in earthworms in turf and placing it upside down on pastures. Using a fork, dig them out of your breeding area and gently put them in buckets. Place about five earthworms gently on dung pats down the middle of paddocks, or more in

large paddocks. After spreading earthworms they spread gradually, clearly indicated by dark green where they have subsoiled and converted dead organic matter into humus and fertiliser which increases the N levels.

I believe that because earthworms don't move far they become inbred. Bringing in some of the same varieties can reduce this and give them hybrid vigour. Do so and check how much more active they become - provided conditions are perfect, with optimum moisture, calcium, other minerals, animal manure and organic matter. You can also move some from the front paddocks of your farm or section (lot or plot) to the back, and visa versa.

To get the hybrid vigour advantage around the farm, take a light bucket and a small spade, or fork to reduce damaging earthworms if your soils are correctly soft and have 40 earthworms per spit. Turn the fence energiser off. Get some from the first paddock and take them to the next paddock, spread them and dig some from there and go to the next paddock, and so on. Once in five years should be often enough.

Results

Ruakura Animal Research Centre scientists and NZ Dairy Board consulting officers visited our farms occasionally to see our many on-farm comparative trials that we've been doing since 1955. Applying our trial results to the whole farm helped us get chosen from the Waikato in 1959 for a week in Wellington with dairy farmers from the other provinces.

In early March 1986 Cor Feyter and two other Ruakura soil, fertiliser and pasture scientists visited our farm on Greenhill Road and said that we'd had rain because our farm was so green and their Ruakura Research Farm three km away was dry and brown. It had been farmed for 90 years and was a better soil type. I pointed out that ours was green and weed-free while the two visible neighbouring farms were not. They then asked what I was doing, "Half metre deep spinner drains every 30 metres, adequate lime and synergisms based on pasture herbage analyses, chisel ploughed in, correct fertilisers and breeding and spreading earthworms," I replied. They didn't then promote any of these simple basics, instead each continued sitting in their ivory towers dreaming about a silver bullet that would allow each to write 'papers' to hopefully make them famous, instead of learning that success is a combination of correct farming basics.

I pointed out the green band down the centre of a paddock was from earthworms spread there. The three disputed that it was earthworms and claimed it must be a better soil type. We walked to it. The soil where there were no earthworms was brown and hard while the green area with earthworms was soft to walk on. We dug in each area and there was silence from the scientists. The soil types were the same, but the earthworm numbers and the improved soil structure told all.

I told my farmer clients about these pasture earthworms (mostly Caliginosa), and most purchased them from John Stemmer of Motueka in the South Island, without one being dissatisfied. New Zealand still needs another Caliginosa breeder. I and many farmers miss the excellent earthworm supply that he provided for decades. Please tell me if you know of a Calignosa breeder. We will give them free promotion for the benefit of all, which would sell many thousands.

A Walton, Waikato, top dairy farmer, after buying and spreading these earthworms over his pastures, said that the grass turned greener as if nitrogen had been applied and the earthworm numbers doubled to 40 per spade spit, all of which were more active. He had fertilised correctly and applied agricultural lime at 600 kg per ha (500 lb per a) per annum annually for decades, so already had more earthworms than most have. During dry periods they went down to about 30 cm. It should be pointed out that he was a top farmer producing top figures per cow and hectare, and stocked at 3.1 Jerseys per ha (1.2 per a) and rearing 36% calves without buying in any feed.

Earthworms consume soil, animal manure, dead pasture and the thatch layer on sod bound pastures, then excrete it in casts, which each year incorporate the equivalent of 200 kg per ha of 45 kg of nitrogen (N), 7 phosphorus (P) and 8 potassium (K) per hectare per annum in plant available forms. These levels are as much as is required by some soils for maintenance. No wonder organic farmers who balance their soils can achieve good production with less fertiliser. They produce nitrogen by consuming organic matter and turning it into manure (casts). The exact amount of N per hectare varies substantially depending on the number of earthworms, the amount of vegetation, the soil, its temperature, moisture level, and the number of grazing animals. Up to 80 kg per ha of N per annum has been quoted. This is a considerable amount equating to 160 kg of urea per ha, so fostering them with optimum drainage,

LimePlus and avoiding pugging is worthwhile.

Earthworms are important in all soils, and especially in grazed pasture soils, because they break down and spread animal manure and aerate the soil that under pasture doesn't get cultivated. Compact soils often become dead soils and breeding grounds for bad bacteria, streptococci, etc.

In peats under pasture, earthworms reduce the frequent cultivation and regrassing costs needed by making the pastures last longer before having to cultivate and resow them, because the topsoil in peat has consolidated until too shallow to sustain pastures. In pumice and sandy soils earthworms improve and deepen topsoils rapidly. See photo below. They indicate good management.

Pastures then keep improving and require less renovation, less oversowing and, depending on the soil type and management, no subsoiling.

It is easy to see the difference between typical inbred earthworms and crossbred ones. The latter when exposed to air and light wriggle around like a fish out of water, while the old ones we had which were inbred (See below) wriggled casually. The difference was amazing.

If unsure about what earthworms can do on your farm, do a comparison as described above with the best earthworms you can get.

I later believed that earthworms could become inbred because they mate and breed prolifically (one increasing to 1,000 in a year) and don't move very far. What made me think this is that a few years after buying pasture earthworms from now retired John Stemmer I and our share farming son-in-law noticed that all earthworms on our farm became much more active. By this I mean wriggled much faster when exposed to the air, and worked the animal manure faster. Our son-in-law noticed the same on his first farm. It could be hybrid vigour working so try moving some of the same variety from and to different parts of the farm and check how much more active they become - provided conditions are perfect with optimum moisture, calcium, other minerals, animal manure and organic matter.

A year after client Grant Sefton near Reporoa, New Zealand, applied lime and then correct fertilisers, based on pasture analyses, he bought and spread 1,000 Caliginosa earthworms. His pumice soils had almost no earthworms, and a very shallow topsoil above sandy pumice. He spread them about six months before I took this photo. This green area was one of many across the paddocks where he had placed half a dozen earthworms.

The green growth is mostly from the nitrogen made by the earthworms, but the improved dark soil and better soil structure that they produced also helped. Earthworms letting air into soil also increases the N content. Hand hoe or cultivate around some plants in your vegetable garden, and not others, as a comparative trial, and see how cultivation lets air in so they green up and grow better. 78% of air is nitrogen as N2 gas.

Earthworms of several types -

1. Clean up animal manure and move the nutrients into the soil over a wider area than the dung pat, so instead of dry dung pats killing the pasture, or small green areas of pasture around dung pats, large areas of green lush pasture develop, which grow more pasture and can be grazed sooner. In this way earthworms reduce P and N leaching, pollution and the waste of animal manure, and grow more pasture. Most environmental bodies and councils do nothing about encouraging good farming practises to encourage more earthworms, apply agricultural like, deepen soils, all to reduce leaching into the underground water.
2. Eliminate pasture-kill by old dung pats; unfortunately earthworms don't do this in dry conditions when they are not working, but are down deep wound up in a knot called devistated.
3. Improve soils and plant production.
4. Dung beetles help move animal manure even in dry conditions. The small ones work in fresh soft manure, but the large dung beetles don’t remove fresh dung because they wait for it to dry before rolling it to their holes for storage to breed in.
5. Remove animal manure, so decreasing the breeding sites for flies and intestinal parasite larvae, all within a few days.
6. Make holes in the soil that help with root growth and allow air, water, lime and fertilisers to

enter the soil.

7. Deepen topsoils.
8. Reduce rain water runoff, increase plant growth and help to provide food for the important soil micro-organisms.
9. Improve soil moisture retention.
10. Reduce soil erosion and fertiliser-wash down slopes.
11. Improve soil aeration that allows deeper plant root penetration.
12. Improve drainage in wet soils. US trials showed that wet soils with earthworms drained four to ten times faster than those without.
13. Loosen soils, allowing clovers to grow larger nodules, so produce more nitrogen. It has to be seen to be believed how big nodules can get in a loose, fertile earthworm-full soil.
14. Take dead vegetation from pasture and turn it into plant food. Earthworms consuming thatch which is dead surface vegetation, reduce or even eliminate facial eczema (FE) spores. See Animal Health > Facial Eczema.

The inaccurate pH measurements and MAF not using pasture analyses caused insufficient lime to be applied for decades, so there were no earthworms or casts in the calcium deficient soils even after applying 3,000 kg/ha of LimePlus, and as shown there was still thatch galore.

To convince the farmer I applied another 3,000 kg/ha of LimePlus per hectare three metres away from the above, which is the amount removed in milk in three years. The substantial increase in earthworm numbers then caused the five earthworm casts shown. The earthworms ate all the thatch and gave thicker stronger ryegrasses and clovers. For more evidence read Minerals in Soils > Calcium and then the Earthworms chapter in Soils.

Facial Eczema disasters in herds are still being reported annually in farming publications, which don't mention causes and give solutions. We eliminated ours in 1958 completely with good farming, applying LimePlus on both farms concerned increasing earthworm numbers from an average of about 5 per spade spit, to 30. This number of earthworms consume all the dead thatch on which Facial Eczema spores multiply and increase pasture production.

When Ca is low (ryegrass 0.6% or lower) applying LimePlus based on a pasture analysis, doubles the pasture yield, paying for its applications and increasing the earthworm numbers, which is worth a lot in more than just Facial Eczema prevention.

15. Stop the build up of thatch (dead pasture on the surface of soils) that can build up to a 3 cm or thicker layer, which repels rain and creates an acid dead surface layer that clover runners don't root into, so get pulled up by grazing animals. Applying agricultural lime is essential to help earthworms remove this thatch.
16. Take surface applied agricultural lime and reactive phosphate powder down into the soil. Superphospates reduce earthworm numbers.
17. Increase soil organic matter that helps soils retain elements such as cobalt that leach out of low-organic matter soils.
18. Create deeper topsoils and deeper plant rooting that reduce the leaching of N and P causing pollution.
19. Encourage the deep rooting of pastures that then grow for longer in dry weather.
20. Eat root nematodes, that are a type of eelworm that penetrate clover roots in particular, causing

the ends of roots beyond the eelworm to die.

21. Improve the soil's structure, which increases soil microbes and beneficial fungi.
22. Make soils easier to cultivate.
23. Increase pasture production because of the above benefits. AgResearch in Palmerston North in the 70s achieved a 25% increase in pasture growth from an area with ten million earthworms per hectare, compared with areas that had none.
24. Eliminate the need to mechanically harrow or drag grazed pastures, which pollutes the pasture and makes it less palatable to the animals at the next grazing.

We have some black earthworms which are average in size, soft and don't appear to do much except increase in numbers slowly. If you now about them - good or bad, etc., please tell us.

Less facial eczema

Lots of animals suffer from facial eczema in many countries without farmers noticing it, or if they do, without knowing the cause. I've seen it in USA, and a dairy farmer client in Canada emailed that he saw it in his calves, after learning what it was, in my article in the USA Stockman Grass Farmer magazine.

In about 1940 farmers in France changed from grazing to 'cut and carry' confinement feeding, because the harvested pasture caused no facial eczema, as it was longer before cutting, and was not cut as low as animals graze. Facial eczema is caused by Pithomyces chartarum, which is a fungus producing a toxin called Sporidesmin that increases rapidly in some pastures during warm and humid weather, after grass minimum temperatures exceed 12° C (54° F) twice, combined with heavy dew or as little as 3 or 4 mm (0.15 inches) of rain after dry hot periods. Heavy rain washes the spores off, but they grow again. Spores are most plentiful near the ground in dead vegetation. Read the Facial Eczema chapter in Animal Health.

Sporidesmin damages the liver when it can't rid the body of wastes fast enough, making the exposed and nonpigmented skin sensitive to sunlight. Counts exceeding 50,000 per gram of leaf are extremely dangerous, or 30,000 for a few months can cause facial eczema. Most animals recover, but some can die. Production of meat, wool and milk suffer, as does fertility. Some animals show no clinical signs, but production is reduced and liver damage can occur and cause their skin to be slightly jaundiced, and the skin on the brisket and just behind the front legs to become a yellowy brown colour. See photo in Animal Health > Facial Eczema.

Liming, where needed, increases earthworm numbers, which reduce the spores. Liming trials I organised on clients' farms showed only one tenth the number of FE spores in pasture that had lime three years prior, and developed large numbers of earthworms, compared with adjacent paddocks that got no lime for five years. These paddocks that didn't get lime had ten times the spore count. One client at Roto-O-Rangi in Waikato recorded a sixth the number of spores on limed paddocks and 20 times as many earthworms in areas that had been limed, compared with adjacent paddocks that had not been limed.

In about 1970 MAF in Palmerston North found that earthworm active soils had fewer facial eczema (FE) spores than soils with no earthworms. Farmers have also found that soils with high earthworm populations have lower FE spore counts, because the earthworms decrease the amount of dead organic matter in which the spores multiply. In 1986 on our second peat farm near Hamilton East we had none, while a neighbour had 20 cows with severe facial eczema.

It is amazing that despite these many benefits, few researchers, agricultural consultants and farmers encourage, breed and/or buy earthworms, and apply enough LimePlus, which is the best form because it includes serpentine, boron and other deficient elements, decided from pasture analyses, necessary for perfect earthworm conditions.

Subsoilers

Many farmers have achieved excellent responses from subsoiling some types of over-drained peat and hard-pan soils with 60 cm wide tips, but not in paddocks where earthworms were thriving, because they do a much better job than any subsoiler will ever do, unless there is an ironstone pan or equivalent that they can't get through. Old-time farmers, who didn't have access to subsoilers, aerators, etc., placed much more emphasis on soil conditions that encouraged earthworms. Today some farmers think

that they can solve soil problems with machinery, chemicals and money, but then complain about high costs and low profits.

Interesting

On 11 May 2010 before the first decent autumn rain, I visited the farm of Peter and Judy Mellow at Bruntwood just south of Hamilton, to decide whether to apply fertiliser or more lime. The pasture analysis was confusing because, as I found out on site, it was a mix of ryegrass, clover and plantain. It showed a good reason for analysing just one grass on its own. See the varying levels in columns A to W in the free Pasture Minerals Analysis spreadsheet.

He had applied LimeMag at 3,000 kg per hectare a year before. It had worked down 7 cm to which depth there were more earthworms that were more active and more moist, while those below were fewer, more sluggish and drier, so had soil sticking to them, blocking their breathing and causing them to move more slowly. More LimeMag was applied.

Breeding earthworms

By now you'll be wondering about how to breed and increase your earthworm numbers. Many farmers in many countries have told me that their earthworm numbers in their soils are fewer now than they were a few decades ago, possibly when more lime and less urea were used. Farmers doing the right things have said that their earthworm numbers are increasing annually. There is no point in buying or breeding and spreading earthworms if your farm is not ready for them, so firstly apply Lime-plus at the required level. To work quickly and effectively, lime needs to have it synergisms (elements that make it perform fast) with it. Read Elements > Calcium and about Lime-plus.

They are easy to breed in a few square metres of soil by adding lime, manure, sheep pellets, blood and bone meal, and reactive phosphate, and keeping it moist. Bins are not necessary. These are healthy earthworms (no soil stuck to them) being bred in a created mound during rainy seasons and lower areas in dry weather. Mix 1 kg of agricultural lime or LimeMag (no other kinds), 1 kg of sheep pellets or other animal manure, ¼ kg of fine sand (for their gizzard) and ¼ kg of blood and bone meal from a farm store and a table spoon full of the best soluble mineral mix, and mix it into a bucket full of lawn clippings over each four square metres. After every second time of doing this spread about a centimetre of soil over it. Sometimes use subsoil. Subsoils have more minerals and who knows what, that can have been depleted from topsoils after decades of farming. Never spread more than 10 cm (4 inches) of lawn clippings at a time or it can go to slime if wet, silage, or mould if dry. Keep the whole heap moist by watering it twice a week in dry weather. Cover it with thin plastic bird netting, or in very wet weather with plastic sheeting or old carpet to stop it getting too wet. In dry areas where watering has to be done, covering can help hold the moisture.

Adding some soil and/or sand occasionally satisfies the earthworms need for them. Lime or LimePlus must be added with every layer of lawn clippings, etc.

keep well watered, and add to it in the same way. After a few months you can start removing compost from the bottom and using it. It should be full of earthworms.

If moisture seeps out, use less water. If because of excessive rain, cover it for a while.

It is not necessary to buy special boxes, drums, etc., that are promoted by some. If you buy them or have some, they must be bottomless or have holes with good soil placed under them, so that earthworms can come and go from underneath, and to allow drainage to prevent anaerobic smelly compost which earthworms will leave, or if they can't leave, will die. If they leave yours permanently it will usually be because it is too dry and mouldy, too wet and smelly, or lacking lime. Also, lawn clippings after too much nitrogen has been applied, and a lack of lime, can cause them to leave. Mixing the compost will also make earthworms move down.

You can breed them in a mound in your garden or build two, metre by two metre U shaped wooden or concrete bins as shown below. Divisions should be steel mesh or boards with holes or gaps to allow the earthworms to move from the worked material to the new vegetation. It always amazes me how they find their way through from what they have composted, to the new material. If separate bins are used, earthworms will have to be moved from the first one to the second one soon after it is started. Place removable boards across the front to hold the material in. They can be removed when forking it out. Place a bird and rodent-proof plastic mesh over the top to keep them out. All rodents (rats, mice, hedgehogs, etc.) eat earthworms.

Fill one side, then the other. A soil bottom (not a concrete or wooden one) is best, to allow the earthworms to go into it for soil, and if the vegetation or compost becomes too dry, too wet, too hot, too smelly, or is fully converted to compost, so has no vegetation (earthworm food) left, they will go into the soil.

Dry manure or vegetation will go mouldy, which earthworms will leave. Aim for 50% moisture levels, which is moist, but does not ooze any water when squeezed. Water should be available to keep the compost moist in dry weather.

Place no more than 7.5 cm (3 inches) of lawn clippings, old hay or silage, weeds and leaves evenly over the area, then spread a kilogram (2.2 lbs) of agricultural lime per square metre (40 inches by 40 inches) over it and tap it into the vegetation with the back of a garden fork. Don't put potatoes in compost because they don't decompose and can become a breeding place for insects that live on potatoes.

Rain or watering will also wash in the lime. Only cover the bin with a plastic sheet on a slope if excessive rain is forecast. Water it before it gets dry, because otherwise mould will form and the vegetation will heat up, causing earthworms to leave.

Add a little fine sand for their gizzard and some soil for the pasture. This is essential for Caliginosa earthworms that will not breed or survive in a vegetation-only compost bin. Caliginosa need animal manure to thrive.

If bins are not possible, earthworms can be bred in soil as above. In rainy seasons make a raised area so it doesn't get too wet. In dry periods use a lower area and water it.

Earthworms like vegetable peelings and some shredded or torn up newspaper and cardboard in small amounts, possibly for the minerals from trees. Earthworms like soft dead leaves from trees, but not the hard ones such as from Elms.

Some people wrongly require compost to heat up to between 53 degrees C (131 F) and 80 C (170 F) for at least 3 days. Earthworms will then not survive and I believe that they do more good in decomposing the vegetation and animal manure safely, than heat that can cause mould and smells and attract flies. Where earthworms are treated correctly as described, flies and smells reduce, and they eat weed seeds, or they decompose.

Allolophana Caliginosa (also called Aporrectodea Caliginosa) are the best pasture earthworms because they are good in both making compost and in improving pasture soils by consuming and moving animal manure well into the soil, as well as aerating the soil. Rubellus and Foetida are excellent in compost, but don't last long in soils under pasture, unless soils never get dry and always have ample dead vegetation and animal manure. Rubellus and Foetida don't move far in soils so don't spread the animal manure very far.

New earthworms are best spread on dung patches down the centre of paddocks in the late afternoon by placing half a dozen about ten metres apart on cattle or sheep manure. After doing this, I've seen the pasture turn greener, and seen the dark green shade move across the paddock as they spread about ten to twenty metres a year.

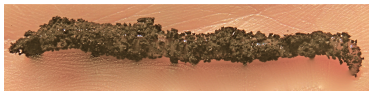
Once you have some new Caliginosa, Longa and Terrestris on your farm, instead of breeding them, Caliginosa can be collected from under dung pats a week or more after it is dropped. Longa will have to be dug out of the soil and Terrestris caught on the surface or half way out of their burrows at night.

There are ways of making earthworms come out of the soil, such as electric fence shocks that I don't favour, and vibration with a garden fork, which is slow. They are easy to breed in lawn clippings, weeds and other vegetation with soil and animal manure and agricultural lime mixed in with the material.

If pockets of vegetation or manure go green (like silage) and don't decompose, it is a sign of the vegetation being spread too thickly without enough lime. Lime raises the pH and starts decomposition and earthworms finish it. They can multiply and consume the material, mixing it and increasing its fertilising quality.

In confinement barns agricultural lime can be spread where the animals stand and in the gutters, then as the chain takes the manure up to the heaps the lime will get mixed in and help decompose the manure with less smell. If flies do come to the manure, spread more lime over the surface and use a fly trap. See Pests > Flies.

Cruelty



This was the only earthworm we could find in the DairyNZ Lye Farm paddock near Hamilton. We felt so sorry for it - what cruelty! A pH of 5.9 told their farm manager that lime was not necessary, when their sick earthworms, their hard grasses pulling out and a lack of clover showed that lime was needed. If pH is going to be used as an indicator, it should be accurately measured and be more than 6.2, which is the level at which pasture earthworms start to thrive and P is more available and aluminium less available, so ryegrass roots go deeper. See Soils > pH.

Composting

Composting vegetation and animal manure reduces the volume by about 60 percent, improving it, leaving less to be loaded, carted and spread on fields and without a smell - provided it is done correctly. Composting of vegetation and animal manure can be clean, odourless and profitable, provided it is done correctly which is very easy. If there are flies or any smell then something is wrong, such as too acid, too dry so goes mouldy, too much nitrates as can be in lawn clippings from too much nitrogen applied to the lawn.

Spread one kg (2.2 lb) of fine agricultural lime per square metre (40 by 40 inches) over each 10 cm (4 inches) layer of vegetation or animal manure. If Ca is adequate in your soils or where the compost is to go, but P is needed, use small amounts of good (fine, soft, low-cadmium) reactive phosphate powder such as Gafsa.

These are our garden compost and compost Foetida earthworm breeding bins. The white on the plants is agricultural lime spread on old discarded Primula flowers. Note the hole I dug in the right bin. Only 15 cm down (6 inches) down is black compost never been mixed.

On the left is the compost made by earthworms from lawn clippings, old flowers and weeds, without any hand turning. Earthworms halved its volume.

The photo below shows how quickly healthy well-fed earthworms can turn vegetation and scraps into compost. The almost decomposed vegetation has been dug up from the hole at the bottom right and shows some earthworms on the left.

Note the galvanised grating that allows earthworms to move to the fresh vegetation after they have decomposed one side. It doesn't have to be galvanised. Planks with gaps can achieve the same.

If part of the compost goes mouldy, apply more lime and water. Keep it well watered, but if moisture seeps out, apply less water. If seepage occurs because of excessive rain, cover it with plastic sheeting. Seepage around compost and manure heaps has to be prevented to ensure it doesn't get into the soil where flies will breed, or into waterways and cause pollution. If seepage can't be reduced, a concrete drainage and catchment system should be installed and the effluent spread on soil, not on plants, which it can burn and even kill unless well diluted.

In some countries the law requires all compost to be on concrete with no seeping to soil. This law is for animal manure, not for ordinary kitchen and garden refuse. A problem with a concrete base is that if the compost gets too dry, too wet, too hot or too mouldy, there is nowhere for the earthworms to go to.

Ample earthworms, clay, minerals and lime can turn vegetation into black compost in not much more than a month, except in freezing winters - without mixing it.

When moving compost and harvesting earthworms to spread on pastures, use a fork, not a shovel, to avoid damaging the earthworms.

Remember compost has to be kept moist, which in dry periods means watering twice a week.

Assess your handling equipment before determining which system to use. Feedlots with adequate cropping land available for the spreading of raw manure might find that composting increases work load, although once organised it is not much. Smaller operations, or those without sufficient cropping land, may find that composting is best.

See Breeding for how to feed earthworms to make compost.

Pastures that are analysed and fertilised correctly with the deficient minerals will grow even faster with animal manure because it is more available than dry fertilisers. This is shown by the lush, healthy,

long grass and clover over dung and urine patches in grazed pastures, and the green even pasture that grows where travelling irrigators spread fresh liquid effluent straight from farm dairies during milking. Spreading composted material can give even more growth. Plants that are given compost are less affected by pests, rust, other diseases and droughts.

However, avoid an excess of animal manure or compost, because nitrogen levels can get too high which increases leaching and nitrate toxicity. Animal effluent is also high in K. See Animal Health > Toxins, and Elements > Calcium to see how lime decomposes effluent, reduces K and nitrates and drought effects.

Wheat on my parent's farm near Greytown, Natal, South Africa, in 1951 that got compost from animal manure and grass bedding, grew far better and had no rust, while the other had bad rust and a much lower yield. It is partly the nitrogen (N) that reduces rust, but not completely, in that applications of artificial nitrogen don't give the same continuous protection against rust in ryegrasses that I've seen from compost, animal manure or high nitrogen-fixing white clover, such as NZ Grasslands Tahora and Kopu 2. So it is best to grow legumes that make the most N and yield the most dry matter. See Pastures > Legumes.

Composting dead animals

This is a massive subject so Google for it using the heading above.

http://www.extension.iastate.edu/Publications/SA8.pdf

http://www.dep.state.pa.us/dep/deputate/watermgt/wsm/wsm_tao/InnovTechForum/InnovTechForum-IIC-Keener.pdf

I would dig a hole deep enough that the bones won't be brought up in the future with a chisel plough, sprinkle five kg of agricultural lime over each full grown animal and another five kg with the soil as you bury it. It should end up with a mound which will sink as the animal decomposes.

Earthworms save manual turning

Another unnecessary recommendation often published is the labour intensive turning of compost. If vegetation and animal manure have agricultural lime and earthworms added, the latter will turn the vegetation and make beautiful compost without any manual turning and without it heating. They can be bred in the same way and then spread on pastures.

Like grazing animals, earthworms like legumes because they have a high feed value, and are easily digested.

Turning is not necessary, and can be a disadvantage, because turning or aerating compost can discourage earthworms. Mixing is a chore, a cost and disturbs the earthworm colonies. Some types are gregarious. Earthworms do not move to or stay near the surface in disturbed compost or cultivated soil, possibly because over millions of years they would have associated loose soil with earthworm eaters such as birds and rodents, so they go deeper. See Enemies below.

Earthworms do it better because their manure is much better than plain decomposed organic matter. Earthworm casts are odourless and water soluble, and will not burn even the most delicate seed or plant. Their casts on the surface of soils bury self-sown or oversown (broadcast) pasture seeds that then germinate to help keep pastures dense.

Calignosa is the best pasture earthworm that also works well in compost, provided the bottom is soil and some soil is added to the compost. In countries where laws require animal manure and/or compost to be on concrete or an impervious floor, spread 15 cm of soil over the concrete and replace it each time the compost is removed. This soil will become highly fertile.

Freezing conditions

In freezing conditions the manure heap should be covered with the open side facing the sun. Correct composting generates warmth that will reduce freezing. It should not get too hot or the earthworms will leave.

Like all invertebrates, earthworm body metabolism slows down and they hibernate at near freezing temperatures. If frozen, they will die. Some react to advancing winter weather by burrowing down to two metres in the soil.

In some countries manure has to be on concrete so earthworms would not be able to dig into the ground. Covering or having the manure in a building warm enough not to freeze would help.

Flies

If the suggestions are followed, flies should not breed in the manure or compost and there should be no smell. However, if the rules are broken, flies will swarm in and create a smelly maggot-infested mess. Anything that discourages earthworms and dung beetles encourages flies. If your feed pads, heaps of animal manure or compost become smelly, the earthworms will leave, so add more lime, sand and soil and turn the compost to aerate it, and encourage earthworms by covering it during heavy rain periods and watering it in dry weather. A sufficient number of earthworms with lime can eliminate smell and flies. If flies settle on the compost, spread more fine agricultural lime over it. Pig (hog) farmers could benefit from this information. Spread lime around concrete, feed pads and anywhere that moisture and manure gather. The lime will encourage earthworms which will consume the manure, dry out the muddy areas and consume fly eggs.

On farms where flies are already in large numbers, you may have to have a flytrap over the heaps of manure. It is a movable frame with black plastic around the middle from one metre up and with a clear plastic turret on top. The newly hatched flies go up and can't get out, won't fly down to the dark so die and drop onto the compost. The trap should be light enough to be lifted off, tilted back or be hinged on a strong pole on one corner for loading manure in and out. See the plan in Pests > Flies.

In USA parasitic wasps for the control of flies are sold by some organisations. Try -

Rutledge Enterprise, 4311 Aztec, Pasadena, TX 77504. Tel. (281) 487 0825.

Beneficial Insectary, 14751 Oak Run Road, Oak Run, CA 96069. Tel. (800) 477 3715.

If you use parasitic wasps, release them in the spring and at regular intervals through summer. By themselves, they are unlikely to control flies completely. Spraying flies can kill the wasps so use all the preventative systems and speak with your neighbours about controls. Flies can travel for many kilometres. See Pests > Flies > Fly Trap.

Flies in paddocks should decrease after you have 20 earthworms per spade spit because they will consume the animal manure that the flies breed in.

Enemies

Birds, rodents, moles, snakes, salamanders, toads, pigs and even foxes are known to eat earthworms, as do centipedes, leeches, slugs and large beetles. Some type of mites are parasites of earthworm cocoons and the cluster fly (Pollenia rudis) are parasites of rosea worms.

Earthworms died after old liquid manure stored over winter in silos in Switzerland became smelly and sour, containing ammonia and sulphur fumes that keep increasing in old liquid manure. If it has to be applied to soils then do so thinly before rain, and ensure that adequate agricultural lime is applied, preferably before it. Better still add agricultural lime to the manure before it goes into the silo or storage bin. If in doubt about this, put some fresh animal manure into two bottles, one with lime and one without and close them. Open and after a few months and smell them.

Urea applied to pastures have halved earthworm numbers on many farms and trials.

Any excesses (water, cultivation, bad manure or fertilisers) or deficiencies (water, manure, organic matter or lime) can reduce earthworm numbers by discouraging them or even killing them, stopping them breeding, and driving them away. Earthworms can travel several metres on the surface at night. Where excessive amounts of nitrogen or potash are applied repeatedly for years on end, the earthworm population decreases until only the large deep burrowing Terrestris remain. This could be partly because high levels of these elements decrease magnesium, sodium, calcium and some minor elements. Another possible reason is that farmers who apply too much nitrogen and/or potash seldom apply enough lime, an essential element for earthworms, and for soils and grazing animals.

Excess artificial nitrogen, direct sunshine onto bare soil, cultivation and cropping, all use up organic matter, and sometimes moisture, and earthworms won't stay where there is no moisture or organic matter.

Some are killed by some sprays such as 2,4-D. One spraying of pasture with 2,4-D halved earthworm numbers on a Waikato farm in two places. Five years of annual 2,4-D spraying almost eliminated them. These were my observations on new clients' farms, and were compared with areas on the same farms that were not sprayed. Both farmers gave up spraying and used my management systems to control weeds, including earthworms which eat weed seeds and grind them up in their gizzards. See

Animals pugging soils, heavy machinery packing it down and heavy stocking-rates seal off the surface of soils in wet weather. The build up of sulphur and carbon dioxide can then gas to death earthworms and soil micro-organisms, changing a healthy fresh scented soil, into a dead smelly one, which, with the compaction by animals, can also kill earthworms. Dig down a few days after pugging a paddock and you'll be surprised. There will be empty (transparent), dying and dead earthworms killed by the soil gases that can't escape through the sealed surface, and the lack of oxygen that can't enter the soil when air is sealed out.

There are many NZ native species of earthworms that have developed in the native bush, but don't thrive in or contribute to pastured and cultivated soils.

Soils that have 20 earthworms per spade spit can lose all except the big deep-burrowing Terrestris after only one year's maize cropping, when sprays and large amounts of N are used, animal manure and dead vegetation cease to exist.

Applying 40 kg per ha of urea has halved earthworm numbers in several farmer client and our lawn comparative trials. Sulphate of Ammonia also lowers their numbers slightly. All N fertilisers and those with sulphates lower the pH slightly, so lime should be applied to maintain the pH and calcium levels. Sulphate of Ammonia has been accused of acidifying soils, because of the water soluble S content, but S is necessary for N to work and the water soluble S in Single Superphosphate does the same. Elemental S has the same effect, but more slowly and gently over a longer period. The same weight of lime as sulphate maintains the pH at the same level.

What adversely affects earthworms also adversely affects soil bacteria and micro-organisms. If poor management kills them, you will end up with a poorer soil.

During the frozen, hot and dry parts of the year, earthworms curl up in tight coils about 30 cm or more below the surface. Darwin found earthworms two metres down below frozen soil. In the moist and fertile areas of farms earthworms remain active even through a fairly dry summer, provided everything else is adequate.

They move to warmer areas (close sun facing slopes) during cold weather and to higher areas in wet conditions, but not long distances.

Some bird species consume earthworms, especially when pastures are short and during cultivation.

Rotary hoes and power harrows can chop them up and kill them. Earthworms don't become two if cut in half, but fronts can grow another tail. Chisel ploughs do the least damage to earthworms, but all forms of cultivation do, especially if prolonged and if birds follow the tractor.

Surveys show that earthworm numbers are about double in no-till cropping, compared with cultivated, and many times more under pasture, especially if grazed, and even more so in pastures where animal manure is spread fresh (old manure can be toxic and kill earthworms). Productive pasture fields will usually have more than cropped fields, primarily because of the large amounts of organic materials that are continually being added to the soil from root growth and subsequent death, plus animal manure. The pasture acts as a buffer against rapid changes in temperature. Pasture fields are not cultivated very often so burrows are not damaged.

I have found that few fertilisers (in this book fertilisers are those other than nitrogen that is referred to as "nitrogen") applied at reasonable rates inhibit earthworms, in fact if an element is low and is applied correctly, even if acid treated P such as Superphosphate, it can increase earthworms and soil organisms. Good reactive phosphate with fine sulphur will increase them much faster, and applying trace elements that are deficient will increase them even faster. An excess of anything will reduce numbers.

Flat worms

by Cameron Slater on March 5, 2014

It seems some flat worms are devastating France's snail population. Snails, one of France's signature dishes, could be off the menu if the country fails to stem an invasion by a slimy worm from Southeast Asia.

The warning is being sounded over a voracious species called the New Guinea flatworm.

It is already on a list of the 100 most dangerous invasive species in the world as it has a relentless

appetite for native snails and earthworms in places where it has been introduced.

Workers at a botanical gardens in Caen, Normandy, called in scientific help after they spotted a strange, dark, flat-as-a-pancake worm among their greenhouse plants.

Reporting in the journal PeerJ on Tuesday, a team of French experts said DNA tests had confirmed their worst fears: Platydemus manokwari has arrived in Europe.

"This species is extraordinarily invasive," said Jean-Lou Justine of the National Museum of Natural History. "I really hope it can be stopped at the earliest stages."Flatworms Arthurdendyus triangulatus (formerly Artioposthia triangulata) possibly from eastern Asia

Another flat worm?

In Ireland they have problems with what they call New Zealand Flatworms (A. Triangulata). I have never seen one or had anyone here in New Zealand mention them, possible because they die in our hot dry summers. There eggs are on the right.

The Northern Ireland Department of Agriculture claim that they have had 6 Flatworms consume 500 earthworms in a square metre in a year, causing decreases in pasture production and an increase in soil compaction. Apparently the higher and drier soil temperatures that New Zealand gets in summer, and which Ireland doesn't get, kills Flatworms. Other countries that don't get high soil temperatures are concerned that Flatworms could arrive, so some governments are banning soil movement. Some countries that already have Flatworms have recorded no noticeable decrease in earthworms.

On graze-l the following was written. "A terrestrial flatworm, probably from eastern Asia, is spreading through the north eastern United States. This planarian, Bipalium adventitium, is tan to yellow with a dark spoon shaped head (half-moon shaped) and a single dark median stripe travelling down the length of its body. Adults reach a maximum of about 10 cm (4 inches). These Flatworms feed aggressively on earthworms, including worms many times larger than themselves. The threat they pose to US agricultural and their forests is under investigation. They reported, "We have conducted studies of the behaviour and ecology of Flatworms. We need to learn more about their distribution on agricultural lands. The flatworm's dispersion through suburban gardens and lawns is well documented, but much less is known about their abundance on farms.

"In USA, if you have seen terrestrial planarians similar to the description above and photos, please contact Pete Ducey, Associate Professor of Biological Sciences, State University of New York at Cortland, Cortland, NY 13045, USA. Email: duceyp@cortland.edu"

Snakes and salamanders also consume earthworms in USA.

Flooding for long periods, droughts and inbreeding all lower earthworm numbers.

I repeat, a major reason if find on farms for a lack of earthworms is simply a lack of agricultural lime and it synergisms as described in LimePlus in Minerals > Calcium, so the first thing to do is check how much soil has stuck to your earthworms. See above.

I'd not heard of Flatworms until reading about them in a UK agricultural journal, which claimed that these cannibalistic Flatworms came from New Zealand in the 1960s in soil on plant roots and are apparently killing off their earthworms. They apparently attack only the Terrestris earthworm, the large deep burrowing one, of which there were many in cool moist parts of UK, but fewer here. Is this because the New Zealand Flatworms have killed them, or is it because they apparently don't thrive at soil temperatures above 20°C?

Flatworms are triangular, but look like a long, purplish-brown flattened slug. They are like a long leech, in that their pointed fronts and ends can stretch quite a bit. There are different species, some have two longitudinal stripes and some are orange coloured. They are found in New Zealand under logs, but to my knowledge have not been recorded as a problem here.

Flatworms do not improve soils, but follow Terrestris earthworms down their burrows and can ingest one in about half an hour. The problem is so serious that the UK government has funded research into trying an eliminate them. Apparently in Ireland they are hated, and are even giving New Zealand a bad name as they go around killing off their earthworms. I know of none in NZ.

They apparently thrive in the cool, damp soils in Northern Ireland and Scotland.

If you know of any in New Zealand please tell me and send photos if possible please. I wonder if it is another case of a mistake. Californian thistles, don't come from there, but from Canada, where they are called Canadian thistles.

Mites

Earthworms have few natural enemies, but some insects including mites are attracted to acid, moist, organic compost heaps if lime is not added. If numbers increase they can cause problems.

White and brown mites feed more on decaying or injured worms so are not a problem in that respect, but they consume much of the earthworm food. High numbers of mites can cause earthworms to stay deep and not come near the surface, and reduce their reproduction.

Red mites are parasitic on earthworms and cocoons and can attach themselves and suck the body fluid. They first appear as small white or grey clusters, resembling mould. Magnification shows clusters of juvenile mites in various stages of development. Adult red mites are bright red, have egg-shaped bodies with eight legs and are smaller than white or brown ones.

Discouraging mites

Maintain compost pH close to 7 or neutral, and avoid excessively wet or dry mouldy or fermented material. Mites stay closer to the surface so surface material can be removed and spread on paddocks. We've never even seen them in decades of composting and breeding earthworms. A few flies and hundreds of midges have swarmed over compost when we've not applied enough agricultural lime. Sprinkling agricultural lime over the compost has made the insects leave immediately, as if we've used a poison spray. Don't use any limes other than agricultural lime with or without natural deficient elements such as in LimePlus, in compost, or in soils for that matter. See Elements > Calcium > Gypsum (calcium sulphate) for the exception.

If you have a mite problem, search the Net for ‘Earthworms + Mites’ and you’ll see hundreds of photos.

No toxic plants

Gardeners can use lawn and small hedge clippings, leaves (especially from big trees whose deep roots bring up minerals), weeds and vegetable waste, provided they are spread evenly and no thicker than about 8 cm (3”). Don’t use leaves or trimmings from wild cucumber, some buttercups, ragwort, Pinus Radiata (Monterey pine) and other conifers, some oak leaves, Yew, Oleandar, Rhododendron, rhubarb, Tutu (a wild shrub in New Zealand that has killed elephants grabbing some from the roadside as they passed on a truck) and other toxic leaves.

Don't add anything that will attract dogs or rats, such as waste human food, unless it is well buried, or the dogs and rodents are kept away. Keep plastic and similar rubbish out of the compost.

Avoid composting Kikuyu, Bermuda, twitch, couch and oxalis roots, which can survive on the edges of the heap and grow in gardens and paddocks where you may not want them. Use a shredder to shred twigs and branches finely to make suitable to compost.

After a few months you can start removing compost from the bottom. Once fully decomposed, the earthworms will move to the next bin if there is access. We have a mesh divider.

Reproduction

Healthy earthworms are active and covered in moist slime called mucus with no soil sticking to them. Calcium-deficient ones are sluggish and dry with soil stuck to them as shown above. In good conditions most healthy earthworms start reproducing at three months of age. The deeper dwelling species lay only about three cocoons a year because they don't have to produce as many because they are more protected from predators than those dwelling closer to the surface that tend to produce up to 80 cocoons a year.

After applying LimePlus and your pasture and soil elements are balanced and soil organic matter (humus) is up, earthworm buying and breeding or should be done, but not before, because they will not thrive or multiply.

Dung earthworms go down deep during dry weather or freezing conditions. Before dying in summer they have usually laid enough eggs to continue their species. These hatch after rain. If the eggs hatch and the new earthworms die because of dry weather or by being killed before they're big enough to make cocoons, they can leave soils without any. This can happen in summers when soils dry out, then rain falls, the eggs hatch, but no more rain falls so they don't grow large enough to reproduce.

The swollen area or ring is the clitellum or sex gland. Once the worm has one, it is ready to breed, which occurs after 10 to 50 weeks, depending on the species and conditions. It contains gland cells that

form the cocoon that holds the worm embryos.

One earthworm can increase to 1,000 in a good year in a good soil, however very few increase at this rate, because of birds, animal hoof pugging, lack of feed and minerals, cold, heat, dry and wet conditions.

Worms hatch from their cocoons after three weeks to several months, depending on species, temperature and soil moisture. The number that can hatch from each cocoon ranges from one to six, depending on the species, the nutrition of the adults laying them and soil moisture, but usually only a few emerge successfully.

Inbreeding

I believe that because earthworms don't move far they become inbred. Modern farming with frequent drains restrict their movement. Bringing in some of the same variety can reduce this and give them hybrid vigour. Do so and check how much more active they become - provided conditions are perfect, with optimum moisture, calcium, other minerals, animal manure and organic matter.

Our share-farming son-in-law, Ian Dobbs, measured the difference in pasture growth with a PastureGauge© and found a 30% increase in DM production. Soils became softer to walk on. Pastures kept improving and required less renovation, less oversowing and, depending on the soil type and management, no subsoiling.

After heavy rain earthworms often come up to the soil surface and move some distance. This could be because they can then move around safely without dehydrating, which could be an evolutionary behaviour enabling them to travel, or be to washed some distance in running water, to avoid inbreeding.

Hundreds of earthworms on our lawn came to the surface and moved in one direction, but they ended on a path and were then stopped by a brick wall. Were they looking for new genes or did they want to go to new fresh soil? This has only happened once, possibly because we now move earthworms around the lawn and garden, like farmers should do on their farms.

Spread them preferably in the late afternoon and when the soil is moist, and place about five earthworms on dung pats down the middle of each one hectare (300 x 33 m) totalling about 50 per ha.

I used to race pigeons, had three families to use for cross breeding, so I didn't experience inbreeding problems, but some pigeon fanciers who inbred too much had 'fly always' whereby most of the flock would fly away never to be seen again, and were not reported in other lofts, so they must go wild or end up in cities, rather than in others' lofts, to avoid in-breeding.

Look how well first Jersey/Holsteins and Hereford/Friesians do.

I wonder if whales beaching is because of inbreeding, caused by the loss of millions of whales that have been harvested over the last few hundred years. Their main source of food has been reduced by drag-fishing. Some beached whales have almost empty stomachs. Read the book on Banks Peninsula, when about 150 years ago with small wooden ships they could catch a dozen whales in a day without going far. Whales are gregarious like earthworms, and keep together in families. One family goes between the Antarctic and New Zealand. Jersey cows in Jersey Island are very small, partly because none are allowed to be imported so they have a small gene pool, and remote inbreeding, as is happening with whales now. See Breeding. In this part of Hamilton a few years ago sparrows died in hundreds, reportedly from salmonella - or was it from inbreeding first.

Un-domesticated species become very similar from line and inbreeding and sometimes decrease in numbers for uncertain reasons. Is it inbreeding?

Anyway I know that bringing in earthworms from other parts of even the same farm increases their breeding and vigour. I've seen the same after moving earthworms to another compost heap.

Buildings

Earthworms can cause small buildings with thin concrete floors to tilt. At Stonehenge in UK earthworms have caused a horizontal stone five metres long by two metres wide to sink unevenly because they had consumed soil under the stone and excreted castings around it. Earthworms like to live under any flat object, such as stones and even plastic. They won't go to the centre of large stones or concrete slabs, possibly because it is too dry there.

General

Earthworms' main food is dead vegetation in and on top of the soil. Some species prefer to feed on

dead plant roots, dead leaves, dead herbage or animal dung which gets partially broken down as it passes through their guts. Other species are said to eat fungi and small micro-organisms. Soil dwelling earthworms will not survive in compost, and likewise compost dwelling worms will usually not survive for very long in soil unless there is ample dead vegetation. In most cases adequate lime is required as they like sweet conditions.

The head of the worm is always located on the end of the worm closest to the clitellum bulge and has some differentiated structures if you can view with magnification. Even though worms can move both forward and backward they usually travel forward. They usually extend their "head" first when crawling.

About six times more earthworms occur under pasture than under crops because higher amounts of organic matter and animal manure are returned to the soil under grazed pasture.

The old tale that if you cut an earthworm in half you will end up with two worms is not true. Only the front may survive, and even then it depends upon where the earthworm is cut whether it is able to regenerate the missing part of its body.

If frozen they'll die, but they usually go deep in cold weather.

Pasture earthworms

Nearly 200 different earthworm species have been found in New Zealand. Most of these species are native to New Zealand. Some are in general much bigger than the introduced species, with some native species reaching 30 cm or more in length and having a diameter larger than a middle finger. Although these species used to be widespread in New Zealand, nowadays they tend to be largely confined to areas where the soil is less frequently disturbed, such as in the forests, in old gardens and in the hills and mountains.

About a dozen earthworm species came in the soil around plant roots by early settlers from Europe. The following five imported exotic species should be present for healthy productive pasture.

Allobophora or Aporrectodea Caliginosa grow to 12 cm, have a round tail and are the same bright brown above and below. Sometimes the dark brown spine can be seen. They are common in good grazed pasture soils and are the most useful. They are topsoil mixers and, depending on the depth of the topsoil, are reasonably deep burrowing, but don't have burrows (holes to which they return as done by Terrestris). Caliginosa feed on soft dead plant litter at the surface, reducing FE spores, and on dead roots below the surface. They are the best earthworms in soils under grazed pastures and break down and spread animal manure. They are apparently more sensitive to pesticides than some earthworms, possibly because they come to the surface. They are excellent in compost heaps and turn lawn clippings into compost in about a month - provided lime is spread over the clippings and they are kept moist.

Allobophora or Aporrectodea Longa grow to 18 cm long, live for up to six years and are brown with a dark head and lighter underneath and towards their short flat tail. They burrow more deeply than all except Terrestris in good soils and leave visible holes, but not as large or deep as the Terrestris ones. Longa are the best soil aerators under grazed pastures. They won't breed in compost bins.

Lumbricus Terrestris (USA Nightcrawler or Dew Worm) grow to 30 cm long and 6 to 10 mm in diameter, live for about six years and lay only a few cocoons each year with up to three babies. Terrestris is brown and lighter coloured towards their large flat tail. They burrow the deepest down several metres and pull plant material from the soil surface down into their burrows for softening and consumption later. They make mostly vertical holes with some horizontal ones near the surface. While burrowing they swallow soil and extract nutrients from it.

They aid soil drainage. They won't breed in containers of any sort. They survive best in undisturbed areas where their burrows can remain intact. They can be particularly useful species in situations where large amounts of organic matter are on the soil surface. In orchards they help in the removal of the large number of leaves that fall annually.

Terrestris don't normally eat vegetation that is in the soil, but eat and/or take down that on the surface, so can starve after ploughing which leaves a surface bare of organic material. With chisel ploughing, no-till or minimal cultivation and pasture farming, vegetation on top feeds them. No-till has its limitations, so never rush in and do a large area. Try it on a small scale for several years on the same

area.

It has been reported that Terrestris can't survive on shallow topsoil over acid soil such as peat, but Waikato organic blueberry farmer Paul De Groot has achieved this by not using acid non-organic fertilisers, and doing it without lime, because blueberries need an acid soil. He showed me them taking leaves down into uncultivated raw peat that had a pH of 4.8. Earthworms doing this helps deepen peat topsoils and reduce the frequency of cultivation and resowing that are a major cost on peat.

Lumbricus Rubellus (Red Worm) grow to 18 cm long, are red/brown on top and very light colour underneath with a long flat tail. It is an important dung and dead vegetation consumer, but has a very short life span in soils. It lays cocoons in summer that hatch in the autumn after rains to give a new generation. If rains in summer cause Rubellus to hatch early and prolonged dry weather follows, most can die before laying, which depletes numbers until they increase again in suitable conditions. I've seen them die out completely on dry soil knobs, but not in low damp areas. Then during wet weather they spread over the whole paddock fairly quickly because they have up to six in a cocoon.

Rubellus and Foetida are dung and compost worms rather than soil only earthworms. They live in pasture soils in or just under animal pats and in compost heaps, but not in soils without dung. After a few months, and after laying several cocoons, they die. They don’t work soils like the ones above, and in soils they have to have animal manure, or lots of decomposing vegetation, to survive.

Eisenia Foetida or Fetida grows to 10 cm long. It is also known as Tiger Worm, Redworm, Red Wiggler, Manure or Compost Worm, Stink Worm, Fish Worm, Dung Worm, Fecal Worm, Striped Worm, and other names. It is recognised by their alternating red and buff stripes on top and very light colour underneath, with a tapered sharp pointed head and the breeding gland nearly half way down the body. They live in animal manure in pastures, compost and organic matter and not in poor soils. Foetida can start multiplying at about two months of age and can lay two to three cocoons a week for as long as there is food, climate and moisture. It is the main earthworm used for producing vermicast, a compost of mainly earthworm casts.

In moist grazed pastures they can thrive and multiply rapidly in the animal manure. When dry weather comes, the cocoons don't hatch, but do so after rain. If the soil then dries up before Foetida have grown and laid, they can die and the cycle ceases. So after droughts their numbers decrease. Some may survive in moist areas, but mostly more have to be brought in and spread. In dry weather Caliginosa and larger earthworms go deep and curl up and remain there until moisture gets to them.

Others

There are other less productive ones which include, Allolobophora chloritica, Amynthas trapezoides and diffringens, and Octolasion cyaneum, none of which are common.

Vermicast

Another name for Foetida is Stink Worm, that could possibly come from the serimone, a smelly repellent it exudes that discourages birds and rodents from eating them. Vermicast from Foetida discourages slugs and snails, so acts as a deterrent when spread over seeds and around vegetables. It also possibly reduces nematodes and other soil parasite numbers in pastures. Some NZ farmers are using vermicast with reactive phosphate very successfully as fertilisers for pastures, maize, grapes and other crops. A user I checked obtained a reduction in Grass Grubs and Clover Root weevils over his whole farm, compared with neighbours. The Ohio State University has found consistently that the addition of relatively small amounts of worm castings to standard horticultural container mixes, and even commercially prepared premium quality container media, has resulted in dramatic increases in plant growth. A trial I did found the same. We now put four earthworms and their compost in with seeds and plants in each pot.

Some commercial Vermicast producers use the paunch contents from abattoirs.

Sources of earthworms

The NZ indigenous earthworms are not very active. There were no pastures as we know them today, so there were no pasture earthworms. Many early settlers commented on their soils and pastures improving following imported earthworms arriving in soil around fruit and other trees.

Ships in New Zealand's early days coming to NZ for wool, meat and butter sometimes used soil as ballast, and this was off-loaded at the ports. The soil contained many earthworms and they gradually spread out from the ports. Farmers seeing the benefits took some to their farms. Today too many farmers think only of urea.

Soil microbes

Earthworms do a great job, but soil microbes decompose even more dead organic matter into humus than earthworms - provided the soil is live and healthy. There are hundreds of different soil microbes and billions in a teaspoon of soil.

Cultivation

When cultivation exposes earthworms, some get eaten by birds, but it has been estimated to be only about 10%.

Good pastures containing 40 earthworms per spade spit can drop to 10 after two years of cultivation and cropping.

A pasture soil in Canterbury was measured to contain around 800 earthworms per m2 (8,000,000 per ha) before it was cultivated and put into arable production. Two years later the earthworm population had declined to less than 200 m2. Conversely, when an arable field with a population of less than 100 m2 was converted to a grazed grass/clover pasture, the population increased to between 400 and 600 earthworms per m2 after only two years, which shows that the earthworms respond rapidly to the changes in management practices.

Irrigation

Irrigation gives earthworms a longer breeding period, so irrigated pastures have more earthworms than dryland or drought affected pastures. Some varieties may even appear to have died out altogether after a dry period, but they will have gone deep and left their eggs behind ready to hatch when the conditions become suitable.

Dung beetles

The large dung beetles roll up semi-dry dung into 2 to 3 cm balls and roll them to their holes where they store them. Females lay their eggs next to them.

AgResearch is apparently importing some of the large dung beetles to check and distribute here. I hope that they firstly do comparative trials between the good that our existing earthworms; Terrestris, Calignosa and Longa do, compared with what dung beetles do, which in my opinion will be nowhere near what earthworms do. Large dung beetles will reduce earthworm feed so earthworm numbers, which is negative in many ways, especially facial eczema control.

Some Australian farmers have found that cattle pour-ons have killed dung beetles, so what do the internal parasite controllers do to our earthworms?

What is AgResearch doing to stop the unnecessary chemical use on and in animals? Nothing, so our tax money and their wasted work seeking overseas beetles, could be another wasteful exercise, with a distress result.

In the 1980's our share farmer son-in-law, Ian Dobbs and I found that correcting minerals in soils, pastures and drinking water, eliminated the necessity for treatment of internal parasites in calves and older cattle, by feeding Solminix soluble minerals, that he and I developed. Most in the 'establishments' and many farmers, still haven't learned this, so they lose money using drenches and not benefitting from faster animal growth, and the pleasure of farming healthy beautiful looking animals. See Dairying > Calf Rearing and Beef Profiting, and others.

Organic farmers have farmed without chemicals, and done well. See Dairying > Calf Rearing, to see organic farmer Margaret Porteous's success, which would have been even better if the organic rules and supervisors had not limited the amount of LimePlus allowed, and had allowed Selcote Ultra.

Some companies promote on TV the pouring of "Pouron" parasite killers on the backs of beef, which is enough to put us and others off eating beef.

What has Ruakura, Massey, Lincoln, MAF, Dexcel, AgResearch, LIC and DairyNZ done about promoting simple basic farming practices that have many benefits, as well as making parasite drenching of cattle extinct, except for Liver Fluke, but correct drainage reduces it, except for areas that flood from

upstream and bring Flukes down. This information doesn't apply completely to sheep because there is no easy way of getting enough deficient trace elements into them, but pasture tissue analysing and fertilising accordingly to get mineral levels in pastures correct, especially cobalt, which is deficient in all sandy and pumice soils and in all other low in organic matter soils, changes pasture from unproductive to finishing land. Spraying Solminix onto pastures can get more minerals into sheep. See Sheep.

Between 1968 and 1984 Australian CSIRO imported over 52 varieties of dung beetles from Africa, Europe and Asia. Each one was reared in the laboratory under quarantine conditions before being released in climatically suitable areas. Of those released, 23 varieties are known to have become established.

Some species released in the warmer part of the continent bred up rapidly at their release sites, and were subsequently 'cropped' and redistributed into other climatically suitable areas, thus ensuring their rapid spread. Has AgResearch contacted the Australian importers to save re-inventing the wheel?

As well as earthworms, it pays to have the very small dung beetles shown here, because they work in our summer dry conditions, when earthworms slow down. They are good in many ways. In hot dry soils, earthworms can't work whereas small dung beetles do. There are many varieties as shown above in many countries, from minute ones the size of a match head that are here and do well in New Zealand, to 3 cm ones I've seen in Australia and Africa. The large ones compete with earthworms for dung.

After I visit dairy farmers, or they read GrazingInfo, many have expressed concern that they pay DairyNZ a lot (an average of $27,000 pa.), but don't get much of any use in return. I agree, mainly on the basics side of ryegrass mineral analyses, improving soils by liming correctly, getting animal stocking rates correct, preventing facial eczema and internal parasites.

Earthworm killing Flatworms in the UK

The so called New Zealand Flatworm, (Arthurdendyus triangulatus), reported to have originated in the South Island, was first sighted in Northern Ireland in 1963, and was probably brought there in the soil of a potted plant. Since then it has spread to almost all parts of the UK, but is apparently most commonly seen in Northern Ireland and Scotland, but not in New Zealand.

They live on mainly Terrestris earthworms, catching them, dissolving them, then ingesting the 'soup'. It reduces the population of local native worms, sometimes severely.

Eradicating and Preventing Flatworms in Your Garden

The flatworm seems to prefer damper conditions, so causes less damage in drier areas or drier soils. It appears to like sheltering under stones, paving, etc., in gardens. A useful way of trapping them for destruction is to lay 30 cm square pieces of black polythene on bare ground held down with stones. If you check these after 24 hours or longer, you might find one or more flatworms sheltering there.

Egg capsules (small black shiny ovoids shown above) are often quite numerous in these spots if an area is infested. These can easily be picked up in the treads of boots and gumboots, so it's a good idea to clean your boots thoroughly after working in your garden, and especially before visiting someone else's garden.

Although some research is currently being done into their natural predators (not enough due to minimal funding), at the moment there is no known treatment for eradicating these worms. The best you

can do is trap them, kill them by squashing, crush any eggs you find, and avoid swapping pot plants with others unless you are absolutely sure that the pot and rootball contains neither worm nor egg.

I've been farming in New Zealand since 1954 and been keen on earthworms, digging to check numbers, moving them from paddock to paddock and from farms to ones lacking them. I've bought earthworms from the South Island for their hybrid vigour when mixed with local ones and encouraged clients to buy them, but never seen Flat worms or their eggs, so wonder if they did originate from New Zealand. They are certainly not like the NZ indigenous earthworm that was in New Zealand bush, and still stays there, and is sluggish and not very active.

Farmers and gardeners if you ever see any, please take photos, kill them, and email the photos to me at support@grazinginfo.com

There has been some discussion and concern locally about the incidence of New Zealand Flatworms in Cromarty, Firth, in Northern Scotland, what damage they can do, and what can be done to eradicate them. Unfortunately this serious pest is present in town gardens in considerable numbers, and can have a very serious impact on the population of beneficial native worms, and hence on the health of soils. The so-called New Zealand native flatworm looks very different to our own native worm which is sluggish and not very active.

Vaughan Jones, ONZM Queen's honour 2013, for services to the farming industry.
Dairying 99% Honours Award 1948. Waikato Most Improved Dairy Farm Award 1959.
International Agricultural Consultant, Journalist, Author of 300 chapter GrazingInfo eBook.
Managing Director of GrazingInfo Ltd with information compiled since 1970.