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Project No. 09-23 (Andrew)

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INSECTS AS POULTRY FEED: A SCOPING STUDY

Summary

The feasibility of feeding insects on different types of waste materials and subsequently feeding insects to poultry was reviewed and examined in this study. A number of insect taxa including silkworms, locusts, fly larvae, crickets and grasshoppers can be safely fed to chickens without compromising the quality of meat. Insects could be reared and fed on a variety of organic waste materials which are available in adequate amounts in different regions. However, the economic viability of breeding and rearing insects on a range of organic wastes needs to be assessed prior to implementing this technique on a commercial basis. In order to be economically feasible, the overall cost of rearing and feeding insects to poultry needs to be lower than the cost of feeding conventional protein sources like grains and soybean meal. Further research should investigate this issue in more detail both establishing small experiments and developing production models which include insects in the poultry diet.

Objectives

The aim of this study was to investigate the feasibility of utilizing insects as poultry feed and what types of insects and life stages could be fed to free range chickens safely and economically with special focus to free range poultry production systems in Australia. To ensure economic viability, a key feature of this study was to examine the prospects of using industrial waste by-products as insect feed and how these waste products could be recycled or modified for their subsequent use as insect feed.

We originally had four aims:

(1) to investigate the possibility and efficiency of rearing different insects for use as a feed ingredient (protein source) in poultry diets, determine the nutritional value of these insects and assess the growth performance and nutrient digestibility when fed to broiler chickens.

(2) to increase the biosecurity of free-range chickens via enhanced feeding systems by developing on-farm feeding systems

(3) increasing the foraging range, diet and exercise of free-range chickens by developing novel feeding methods using live insects and locally sourced waste material

(4) to assess the possibility of increasing colour of egg yolk through manipulation of live insect diets and nutrient intake.

However, due to the tight time frame of this project, we were restricted to conducting literature searches, farmer surveys and waste services surveys only. No pilot studies or experimental assessment of insect rearing, foraging range or yolk colour enhancement was carried out.

Introduction

Protein sources of animal origin have traditionally been used for livestock animal feeding. However, there is a serious risk of introducing diseases by this practise and consequently feed ingredients containing or contaminated by animal matter from any source must no longer be fed to livestock in Australia. Furthermore, many of the traditional ingredients used in poultry diets are forecast to be in short supply within ten years. Thus, there is a need for identifying alternative protein sources that meet dietary requirements and reduce feed costs.

The increase in world's human population necessitates an equivalent increase in food supply which can be achieved through improving the efficiency and cost-effectiveness of agricultural production systems. The poultry industry is highly efficient with feed conversion rates that make chicken one of the economically viable and important sources of meat for human consumption. However poultry production is based on grain, itself used for human consumption and therefore a high value commodity which combined with the increasing consumption of chicken has seen the cost of grain increase significantly. The increasing cost of grain has prompted the poultry industry to explore alternative sources of poultry feed.

Insects may provide an alternative protein source in poultry feed. Insects have high nutritive value, not only in proteins, but also in fats, minerals and vitamins. Once selected and with appropriate breeding methods, suitable species would be able to provide a reliable and sustainable source of high-quality protein. In addition, if the insect species are fed on alternative food sources or waste products, they may add value to animal agricultural industries.

Hundreds of insect species have been used as food for a range of animals. Some of the more important groups include grasshoppers, caterpillars, beetle grubs and sometimes adults, winged termites, bee, wasp and ant brood (larvae and pupae) as well as winged ants, cicadas, and a variety of aquatic insects.

Protein content of edible insects ranges from 30% (wood worms) to 80% (some wasp species). Insects generally have a comparable, if not higher, amount of calories/100g compared to cereals, vegetables, legumes and meats. In addition, edible insects have a diverse range of mineral salts (e.g. Na, K, Ca, Zn, Fe, Mg) similarly, comparable or in higher amounts than conventional human food stuffs (such as cattle, fish, turkey, milk and eggs). Insects also have good conversion efficiency due to their poikilothermic nature not needing to maintain their body temperature. For example, crickets convert plants into biomass five times faster than cows. If reared on waste organic matter and waste materials, insects may act as bio-transformers converting organic bio-wastes into animal biomass rich in proteins and suitable for use in animal nutrition.

Insects' potential role in agricultural diets has not been fully exploited and culturing and rearing of insects as animal feed is not well established (apart from classic examples such as *Apis mellifera* and silk worms). However, generally rearing insects do not need complex infrastructure and their care is simple.

To alleviate this problem, one option being considered is the use of insects as supplementary poultry feed. Approximately, 2,000 species of edible insects have been identified throughout the world for human as well as animal nutrition (Ramos-Elorduy 2005). The number of edible insects for human consumption in different countries as reported by DeFoliart (2005)

is presented in Table 1. A large number of studies (Teotia and Miller 1973; Finke, Sunde et al. 1985; Anand, Ganguly et al. 2008) have investigated the suitability of insects as poultry feed and their findings indicate that hundreds of classes of insects, e.g. fly larvae and crickets, could be safely fed to chickens. Research has shown that some species of insects could be produced on a mass scale for human consumption with insects already on the menu in countries like Thailand, Japan, Mexico, Angola and Zaire. DeFoliart (1992) reviewed some of the economic and nutritional aspects associated with the use of insects for human consumption and reported that a wide variety of insects including grasshoppers, caterpillars, beetle grubs and adults, aquatic insects, termites, ants and cicadas have been used as human feed.

Table 1. Number of edible insects reported from different countries*

Country	Number of each taxon			
	Orders	**Families**	**Genera**	**Species**
Burma	7	14	17	17
China	10	30	36	46
India	7	17	22	24
Indonesia	8	15	20	25
Japan	11	19	22	27
Philippines	6	13	17	21
Thailand	10	31	69	80
Vietnam	8	18	20	24
Australia	7	22	39	49
Papua New Guinea	11	22	31	34
Congo	7	15	25	30
Madagascar	7	15	22	22
South Africa	7	16	32	36
Zaire	5	21	47	62
Zimbabwe	7	14	25	32
Brazil	7	14	19	23
Colombia	8	20	36	48
Mexico	10	42	99	136
USA	10	27	53	69

* Adapted from DeFoliart (2005)

Insects have been used as a food source for a number of different species of animal, however relatively few studies have focused on incorporating insects in the diets of domestic livestock (Finke, Sunde et al. 1985). The key areas that need investigation are what to fed insects which could be bred and reared on a commercial basis for poultry consumption. The benefits and disadvantages associated with the use of insects as feed for free range poultry are reviewed briefly in the following section.

1. Characteristics of insects as food sources

Insects have characteristics which make them an excellent alternative for use as feed for animals and humans (Ramos-Elorduy 2005). Some of the important characteristics of insects as described by Ramos-Elorduy (2005) are summarised below:

(a) Large biodiversity and short life cycle: Depending on dietary and other requirements like size, winged or wingless, physical and bio-chemical composition, a wide range of insects are available for use as poultry feed. Also, short life cycle would allow breeding insects in large numbers on a regular basis.

(b) Prevalent in most ecosystems and colonize a wide range of habitats: Many insect species are found in abundance in most geographical regions and some exhibit rapid and relatively simple developmental strategies, making their commercial breeding potentially straight forward and cost effective.

(c) Large population and biomass: A short life cycle facilitates multiplication into a large population and biomass which can be easily used as poultry feed commercially.

(d) Low breeding costs in general: Many insects do not require a sophisticated and expensive infrastructure for breeding which makes them an excellent choice for use as poultry feed.

(e) Breeding is simple and can be controlled easily: Breeding of insects can be controlled in a relatively simple manner without involving complicated infrastructure and expensive labour costs.

(f) Contain good quality of proteins: Insect protein has been found to be of better nutritional quality than most proteins from grains and other sources of plant origin.

(g) High reproduction rate: The high reproductive rate of insects makes them a good source of supplementary feed for poultry.

(i) Better feed conversion efficiency than most other animals.

2. *Nutritional value of insects*

A large number of previous studies have focused on investigating the nutritional contents of a wide variety of alternative foodstuffs that could be used as protein or mineral supplements for animals including poultry. Previous research by Ramos-Elorduy (2005) and Bukkens (2005) has shown that insects have a high nutritive value in terms of proteins, fats, minerals, and vitamins. The nutrient composition of different types of edible insects consumed by humans as per Bukkens (2005) is presented in Table 2.

Table 2. Nutritional content of different species of common edible insects*

Food insect	Country	Moisture (g/100g edible portion)	Energy (kcal/100g)	Crude Protein (% w/w)	Total fat (% w/w)	Ash (% w/w)	Crude fibre (% w/w)
Caterpillar of moth (*Imbrasia ertli*)	Angola	9.02	375	48.7	11.1	14.4	N.A^.
Caterpillar (*Nudaurelia oyemensis*)	Zaire	7.0	N.A.	56.8	11.3	3.5	N.A.
Mopane worm (*Gonimbrasia belina*)	Africa	6.1	444	56.8	16.4	6.9	9.6
Witchetty grub	Australia	38.8	417	13.2	36.2	1.2	N.A.
Bogong moth (*Agrotis infusa*)	Australia	49.2	301	26.8	19.8	2.7	N.A.
Spent Silkworm larvae	India	18.9	N.A.	48.7	30.1	8.6	N.A.
Silkworm (*Bombyx mori*)	East Asia	60.7	229	23.1	14.2	1.5	N.A.
Ant eggs (*Itlog langgam*)	Philippines	71.0	128	17.4	3.8	2.8	N.A.
Tree ants (*Oecophylla virescens*)	PNG	78.3	111	8.9	5.8	1.3	N.A.

* Data derived from Bukkens (2005); N.A. - Not available

Studies have shown that insects are nutritionally rich in proteins, fats, vitamins and minerals (Bukkens 2005). For example, in India, pupae of silkworms (*Bombyx mori*) are fed to chickens after oil has been extracted. The feeding of fly larvae (*Musca domesticus*) to free range chickens could assist in the recycling of animal manure in addition to the development of insect based recycling systems for the conversion of organic waste matter into feed supplements (Gullan and Cranston 2005). The selection of edible insect species and the subsequent development of their appropriate breeding programs would provide a consistent supply of high-quality protein for livestock consumption (Ramos-Elorduy 2005). Since protein is regarded as the most expensive ingredient in the diets of poultry (Teotia and Miller 1973), feeding insects appears to be an economically viable option.

The nutritional value of individual edible insect species needs to be evaluated prior to their use on a large scale. Furthermore, insects can be used to convert different types of organic waste materials into animal biomass rich in proteins which can be later used in animal nutrition (Ramos-Elorduy 2005). Since most insect colonies feed on biological or organic waste materials, the option of utilizing waste materials from a range of industries as potential insect feed needs investigation. The biological or organic waste materials are available in

plenty which will provide a means for the proper utilization of industrial waste materials. Previous study by Ramos-Elorduy (2005) has shown that insects fed on organic waste matter developed well and exhibited better feed conversion efficiency and therefore generated.

Previous review by Ravindran and Blair (1993) has demonstrated that essential amino acids derived from animal protein supplements are superior to those obtained from plant protein supplements in poultry feed formulations. Similar findings were reported by Bukkens (2005) who stated that the amino acid composition of most insects is better than that of legumes or grains. Anand et al. (2008) stated that acridids have a higher proportion of protein content in comparison to conventional fish and soybean meals. The authors concluded that acridids could be used as high protein feed supplement for domestic livestock. de Vries (2000) stated that the overall crude protein consumption is significantly increased by the intake of insects and weeds. Teotia and Miller (1973) fed fly pupae to broilers and found no significant differences in carcass quality or taste in comparison to birds fed conventional soybean meal. In another study, Finke et al. (1985) investigated the impact of feeding corn-cricket (*Anabrus simplex*) diet to broiler chicks and reported that no adverse impact on taste was evident. These findings indicate that the scope of feeding insects to poultry has immense potential. However, further research is required to examine the impact of feeding different species of insects on carcass quality, growth rate, and palatability prior to the widespread application of this system of feeding chickens on a commercial basis. Some insects produce toxic chemicals and serve as vectors or intermediate hosts for pathogenic microorganisms like bacteria and viruses, and helminths like worms. Therefore, the risk factors associated with the use of insects as feed must be assessed prior to their use on a commercial basis (DeFoliart 1992).

3. *Processing or treatment of insects prior to feeding poultry*

There are species of insects which are nutritionally rich in proteins and other minerals however due to the toxins secreted they cannot be used as feed for poultry. Therefore, processing or treatment of those insects needs to be undertaken before they could be safely used as poultry feed. Processing of insects would be required for ease of blending or addition to other feed ingredients or for the ease of handling and storage. Processed or dead insects are likely to be easy to handle and incorporate into existing feeding regimes for both free range and caged birds. Live insects may be fed to chickens raised on a free range farm which appears to be an economical option but live insects pose a risk of escaping into surrounding ecosystems especially if they have wings. This risk could be reduced by breeding wingless insects. Additionally, live insects may have potential difficulties in handling, incompatibility with current automated feeding systems and a potential to act as vectors in the transmission of bacterial and viral diseases.

4. Rearing techniques for edible insects

Once edible insects have been identified they can be bred on a large scale basis for feeding chickens. For any poultry fed to be economically feasible insect production costs must be lower or equal cost to conventional grain feds. Therefore a key component of any research must be to develop low cost insect rearing systems. There are potentially significant costs involved in rearing insects, namely insect feed, labour and transport.

4a. Sources and availability of waste materials

In general, the different types of waste materials commonly available on poultry farms are poultry manure, dead birds and egg shell wastes. In majority of farms, poultry manure is either sold for use as a fertilizer for agriculture or utilized on the farm itself for growing crops like Lucerne and Sorghum for feeding the birds. The types of waste matter generally available in different regions excluding poultry farms are green waste, food factory waste and industrial waste. A significant amount of waste obtained from the farms and elsewhere is used for composting. The waste could be used for rearing insects and further studies can investigate this issue on a case by case basis.

4b. Insectary Requirements

Rearing and breeding of insects will require necessary equipment, techniques for handling, and hygiene measures. It will also involve labour and transportation costs which need to be assessed beforehand. However, a potential risk of spreading of animal as well as human diseases through insects exists when insects are bred in large colonies. Housing can be as simple as a 20L drum with egg cartons and green waste added regularly (for grasshoppers), through to temperature and humidity controlled environmental chambers.

5. Reduction in the use of pesticides in farming systems

Some species of insects which are a pest to crops can be harvested for use as feed for animal nutrition. This would reduce the need for chemical insecticides and therefore reduce environmental pollution. The use of insects in poultry ration may also improve the palatability of chicken meat. For example, it has been reported that in the Philippines free-range chickens fed on grasshoppers are much superior in taste and have a higher market price than those fed on conventionally used commercial feed. In situations where insects could be harvested from the wild, such as during early swarming of locust plagues, it may serve as a means for the biological control of some pest species in agricultural systems. This in turn will also lead to a reduction in the widespread application of chemical pesticides (DeFoliart 1992) thereby reducing environmental pollution.

6. Reduction in organic pollution

The reduction in organic pollution can be achieved through recycling of agricultural and forestry waste material which can be later used as feed for insect colonies. Further research could identify insect species that grow well on plant and tree wastes.

Further research and challenges in using insects as feed for free range poultry production systems

One of the major challenges in using insects as poultry feed will be to persuade industry people in adopting the new technology once appropriate insect species along with adequate breeding methods have been identified.

Feedback or response from regional councils: Waste management officers from Armidale and Gloucester regional councils were contacted to get information regarding

amount and types of wastes available in respective areas and whether the wastes are recycled or disposed at a later stage.

Impact of including insects in poultry ration: Previous research has shown that feeding insects has increased or improved production in both layers and broilers.

Industry and Poultry Producer (Case Study) Reports

In general the following points were raised:

1. Identify the amount and types of industrial wastes that are produced in free range chicken production areas (Sydney Basin, Stanthorpe, Stroud/Booral) and whether industry people are willing to give access to those wastes. Different types of wastes that could be used for feeding insects can be divided into two main categories as follows:

    a. **Organic or biological wastes**: These wastes may come from on-site or from local industries. The imperative here is that the product must be cheap to use, cheap to re-locate (if necessary), and easily handled by the farmers. Poultry farmers may be reluctant to use waste materials obtained from another farm or property due to likely chances of infection (Bio-security). A possible solution to this problem is further treatment and/or processing of the waste material to make it safe for insect consumption and subsequently for poultry consumption. Some examples of biological waste materials may include brewery waste, faecal waste from poultry farms, green wastes, fish wastes, sugar industry wastes, dead birds etc. However, it needs to be investigated whether any harmful toxin would reach humans via the food chain and also the cost associated with the treatment.

    b. **Non-organic or chemical wastes**: This type of waste material may also require treatment or processing before being fed to the insects. For example, food factory wastes. For example, we spoke to the waste manager of cereal and food company Sanitarium at Coorangbong. They produce 40 tonnes or organic waste per week which they call a biosolid, described as 10 - 15% solid/water based filter press chelate. They also produce waste liquid soy milk.

2. To assess whether the feasibility of feeding insects on industrial waste material will be economically viable option. This will encompass several factors like the distance between place of breeding of insects and the poultry farm, and the transportation costs of waste matter from its place of origin to the insectary, etc.

3. Contact farmers involved with free range poultry production and extract more information relevant to this field of research.

The economics of breeding and rearing insects on different types of waste materials and subsequently feeding them to chickens needs to be assessed. This could be achieved by setting a field experiment on a small basis. To achieve this, an economic model could be developed (using computer simulation) for a small scale experiment with variables like the number of birds, proximity of insectary to birds shed, type of production system, types of insects, etc.

Meeting with Mr. Colin Quast Jr.: Kootingal turkey farmer:

Mr. Quast Jr. was very cooperating and was quite impressed with the idea of feeding insects to turkey. He said that he would be willing to try this option at his farm provided it does not affect the bio-security at the farm. He also would be willing to provide space in his sheds in order to set an experiment and perform other research related work.

Meetings with Council representatives about the use of waste products

Dr. James Turnell at Armidale Dumaresq Council was contacted in order to derive some relevant information with regard to the recycling of waste material for use as poultry feed. He informed that a large proportion of waste matter collected in and around Armidale is either recycled or used for composting. Additionally, the wastes from food outlets like restaurants and cafes get mixed with other harmful waste which makes it difficult to be recycled for feeding insects. Dr. Turnell suggested that the cost-effectiveness of the technique of rearing insects on waste matter should be investigated prior to proceeding with the current project to the next stage. He was of the view that industry would be willing to feed insects to poultry only if it is economically viable.

Summary of discussion held with Mrs. Ivy Inwood and Mr. Roy Inwood (Country Range Farming, Toowoomba)

Mrs. Ivy Inwood and Mr. Roy Inwood run a layer farm on the outskirts of Toowoomba. Approximately 90,000 and 10,000 birds are reared on a free-range and cage basis, respectively. During summers, the maximum temperature reaches about 43 degrees and in winters, the minimum temperature is about -6 degrees, and summer season lasts longer than the winters.

The following points were discussed:

1. **The amount and type of waste matter produced on the farm**: The different types of waste materials produced on the farm are poultry manure, egg shell waste and the dead birds (approximately 100 birds die every day). The number of dead birds on a daily basis is quite significant and could serve as a medium for feeding insects. The poultry manure is used primarily for the cultivation of agricultural crops like barley and Lucerne on the farm which are later used as poultry feed. The egg shell waste and the dead birds are disposed off in collection bins and collected on a weekly basis by a private waste collection company (Absolute Liquid Waste Services, Toowoomba, West Queensland). The waste material is subsequently used by the company for

composting. The waste from the crops after harvesting (crops stubble) could serve as a potential insect feed.

2. **Willingness to adopt new technology of feeding insects to free-range chickens**: Mrs. and Mr. Inwood said that they would be willing to accept the new technology of feeding insects to chickens on their farm provided it is simple and cost-effective. They also said that other free range farmers may also be keen to know more about this technology provided it is easily accessible and cheap. This is due to the fact that the production costs have increased significantly especially due to rise in the prices of commercial poultry feed and labour. Therefore, alternative cheap protein sources that can be used in chicken feed need to be identified.

Mr. Roy Inwood showed the waste bins used for storing egg shell wastes and dead birds. The egg shell bin acts as a breeding place for houseflies (and maggots) which later escape to the surrounding ecosystems. Therefore, the prospects of breeding maggots fed on such waste matter on a large scale appear to be promising. Besides, other species of insects that feed primarily on decomposing waste material, and are less likely to act as vectors in the spread of bacteria and other micro-pathogens could also be reared on dead birds and egg shell wastes.

3. **Further questions**: Mrs. Inwood asked what type of insects would be used for feeding chickens and how would they be bred in large numbers for feeding approximately hundred thousand birds on their farm. She asked whether insects would be bred on the farm or away from the farm and whether the insects would be with wings or without wings. She suggested that abattoir and fish wastes could also be utilized for feeding insect breeding colonies. There is a potential to assess the use of dead birds and abattoir wastes as insect feed since the latter type is generated in large amounts on a daily basis. The dead birds could be used to produce meat or blood meal which could serve as an important ingredient in poultry ration.

4. **Further research**: The economics of breeding insects needs to be assessed prior to the actual implementation of the new technology on a large scale basis. Additionally, what species of insects could be bred economically in large numbers needs to be investigated. Furthermore, the impact of feeding different species of insects on the palatability of chicken meat should also be examined.

Summary of discussion with Mr. Bede Bourke (Cage layer farmer in Tamworth)

Mr. Bede Bourke runs a layer farm (cage system) close to Tamworth. Approximately, there are 53,000 birds (27,000 birds per batch).

The points discussed regarding different types of waste materials produced on the farm are as follows:

1. **Poultry manure**: Approximately, 20 tonnes of poultry manure is produced per week which is used as a fertilizer for the cultivation of crops like wheat, barley and sorghum on the farm.

2. **Dead birds**: The mortality rate is very low which is 1.7% and dead birds are disposed in the rubbish tip for composting.

3. **Egg shell waste:** The egg shell waste is produced at the rate of 10kg per day and is used for composting. The amount produced is not significant.

Therefore, the main waste produced on the farm is poultry manure which is currently utilized for agricultural purposes. Mr. Bede Bourke said that the idea of new technology of feeding insects to chickens is impressive but it should have following characteristics prior to its actual implementation on a commercial basis:

1. The new technology should be user friendly and simple.
2. The efficiency of production should not get affected by feeding insects to chickens.
3. The technique must be cost-effective.
4. The insect meal should be available in bulk in order to avoid problems with grinding and mixing in the feed mill.
5. The insect meal should be a dense type of protein so that it gets mixed properly in the final ration. This is especially applicable for cage production systems where birds are fed with a meal which is made of different types of feed ingredients.

Since feed is mixed on the farm and birds are reared in cages, live insects cannot be fed directly to the chickens. Therefore, insect meal needs to be prepared prior to mixing it with other feed ingredients. Currently, conventional protein sources like soybean meal, cottonseed meal, canola meal and meat meal are used in the feed. They are expensive and some of them are imported from Argentina and the United States and are therefore not always readily available. Therefore, alternative protein sources for poultry feed need to be investigated. This appears to be advantageous since insects can be reared anywhere and waste products can be generated from a wider pool including abattoir and poultry farms. Besides, the costs associated with breeding and rearing of insects would be relatively lower than those of importing feed.

Implications

There exists great potential in utilizing insects as feed for the free range poultry production systems. A preliminary assessment of the costs and other factors associated with the commercial breeding of insects for poultry consumption is required. Initially, small numbers of different insect species need to be bred and fed to chickens in order to investigate any possible side effects on growth rate and palatability of meat. Later, those species of insects which are easy to breed and rear and also which have no deleterious impact either on chickens or on the surrounding ecosystems could be bred and fed to free range chickens on a large scale basis. Further research will aid in determining the influence of feeding insects on growth rate and other traits of economic significance in poultry production.

Recommendations

This scoping study has recognised the value of suing insects as potential protein sources for free range poultry. The next stage of this research is to initiate trails of viable insects to assess their nutritional requirements and energy expenditure identified from the four initial aims

Aims of future project

(1) To investigate the possibility and efficiency of rearing different insects for use as a feed ingredient (protein source) in poultry diets, determine the nutritional value of these insects and assess the growth performance and nutrient digestibility when fed to free-range chickens.
Methodology: To assess feeding efficiency and energy utilisation of insects of a range of different waste products we will use standard growth and consumption rate measurements under laboratory conditions.

(2) To increase the food security of free-range chickens via enhanced feeding systems by developing on-farm feeding systems. Once appropriate insects and waste products have been tested under laboratory conditions we would set up experimental feeding trails on free-range farms. Here we will assess the viability of bringing waste and/or insects onto the farm and determine logistics and costs of setup and continued maintenance.

(3) To supplement and improve the diet ,increase the foraging range and exercise of free-range chickens by developing novel feeding methods using live insects and reared locally sourced waste material. Here we will assess the movement of chickens using a Before/After –Control/Impact (BACI) design to assess the usefulness of insects in increasing poultry movement and the amount of exercise that they carry out with and without supplementary foraging.

(4) Increase colour of egg yolk through manipulation of live insect diets and nutrient intake. Here we will assess yolk colour again using a BACI design using free-range chickens to determine if insect foraging impacts on egg physiology and quality using standard methods.

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Plain English Compendium Summary

Project Title:	
Project No.:	09-23 (Andrew)
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Objectives	To investigate feasibility of feeding insects to free range poultry
Background	Protein sources of animal origin have traditionally been used for livestock animal feeding. However, there is a serious risk of introducing diseases by this practise and consequently feed ingredients containing or contaminated by animal matter from any source must no longer be fed to livestock in Australia. Furthermore, many of the traditional ingredients used in poultry diets are forecast to be in short supply within ten years. Thus, there is a need for identifying alternative protein sources that meet dietary requirements and reduce feed costs. Insects are an ideal candidate for food supplantation since they can be cheaply fed and bred on different types of waste materials. They also have the potential to increase the foraging range, diet and exercise of free-range chickens, as well as enhance egg yolk colour.
Research	Identification of waste matter available for insect rearing and willingness of poultry farmers to adopt new technology
Outcomes	Poultry farmers are willing to adopt new technology provided it is easy to use and economically viable. Waste products to be used as insect food must be locally available and cost effective to use, and not impact on farm quarantine or bio-safety protocols. Many different insects and waste products could be sued depending on the local circumstances of the farmers and waste producer.
Implications	Insects that can be cheaply reared on waste materials are able to enhance poultry movement and foraging within a free-range poultry coup. Field based trails need to be carried out to determine the viability of using insects as a large-scale food supplement in the poultry industry.
Publications	Insects as Poultry Feed – A Scoping Study. Australian Poultry CRC Final Report