A Review of the Arthropod-Related Sections of the Hawai‘i Dairy Farms Draft Environmental Impact Statement

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Prepared for

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I. EXECUTIVE SUMMARY

Hawai‘i Dairy Farms (HDF) proposes to establish a dairy farm on 557 acres of agricultural land in Māhā‘ulepū Valley on the island of Kaua‘i. HDF would initially establish a herd of 699 mature dairy cows, and contemplates increasing the herd size to 2,000 dairy cows at a later date. A draft environmental impact statement (DEIS) was prepared to analyze the potential impacts and mitigation measures associated with dairy operations at HDF.

Pacific Analytics, LLC performed a review of the arthropod-related sections of the DEIS. The purpose of this review is to identify shortcomings of the DEIS, point out information that was not included in the DEIS, find sections where insufficient analysis was performed, show potential problems, and identify missing information.

The review is arranged in four chapter dealing with major arthropod-related topics, Pest Flies, Pest Control, Dung Beetles, and Hawaiian Native, Threatened and Endangered Species.

Pest Flies

Fly Species from Dairies Identified in *An Evaluation of Fly Breeding and Fly Parasites at Animal Farms on Leeward and Central O‘ahu*[2]

Stomoxys calcitrans (Linnaeus) – Stable Fly
Haematobia irritans Linnaeus – Horn Fly
Musca sorbens Wiedemann – Dog Dung Fly
Musca domestica Linnaeus – House Fly
Hydrotaea chalcogaster (Wiedemann) – Small Blue Fly
Tricharea occidua (Fab.) – Flesh Fly
Ravinia anxia Walker – Flesh Fly
Ornidia obesa (Fabricius) – Green Hover Fly
Eristalis arvorum (Fabricius) – Hover Fly
Hermetia illucens (Linnaeus) – Black Soldier Fly

- ✯ The DEIS states that there will be no impact due to 699 cows, but fails to address the impacts of significant amounts of manure and the number of pest flies that will breed in that manure.

- ✯ The DEIS states that qualitative or quantitative analyses were conducted for pest species, but fails to include those analyses for public comment.

- **Biting Flies**

There are two species of biting flies associated with dairies, the stable fly and the horn fly.

- ✯ The DEIS fails to discuss the dispersal capability of biting flies to other properties on Kaua‘i.

- **Nuisance Flies**

There are at least six species of nuisance flies on Kaua‘i.

- ✯ The DEIS fails to evaluate the potential impacts of nuisance flies on nearby properties on Kaua‘i.

- **Mosquitoes**

Mosquitoes are not dung-dwelling flies, but the proposed dairy could potentially generate large populations of these pests in standing water, ponds, ditches, and pasture divots.

- ✯ The DEIS does not mention mosquitoes, and includes no analysis of the potential impacts by mosquitoes on HDF neighbors or native Hawaiian endangered birds.

Pest Control

- **Integrated Pest Management (IPM)**

  - The DEIS states in several places that HDF will use Integrated Pest Management (IPM) measures and an IPM program to control pest flies at the dairy, however, the DEIS does not provide an actual IPM plan or details of how various control measures would be integrated.

  - While the DEIS mentions some measures HDF would take to control pests, it does not describe how those measures would be integrated into an effective program.

  - The DEIS also states HDF would use Best Management Practices to control pests, but fails provide a Best Management Practices plan.

- **Chemical Controls**

  - The DEIS states that HDF will use chemical methods to prevent any spike in pest populations, but fails to mention:

    - Which chemicals will be used
    - What the thresholds are for chemical application decision-making
    - What quantities of chemicals will be applied
    - Where the chemicals will be applied
    - Against which pests the chemicals will be used

  - The DEIS neglects to address the effectiveness of chemical controls on target species.

  - The DEIS fails to consider impacts of chemical control on dung beetles and other non-target arthropods.

  - The DEIS fails to provide any information about chemical control of mosquitoes.

- **Mechanical Control**

  - The DEIS provides no details about:
    - The types of mechanical devices to be deployed
    - The number of mechanical devices to be deployed
    - Where mechanical devices will be deployed
    - How long mechanical devices will be deployed
    - The effectiveness of the mechanical devices
    - What constitutes a "spike" in pest populations and how they would be detected

  - The DEIS neglects to discuss the effectiveness of mechanical devices HDF would deploy.

- **Parasites and Predators**

  - The DEIS states that HDF proposes to release insect parasites and predators to control fly populations, but fails to provide information about:

    - What fly parasite and predator species will be used at HDF
    - What is the source of parasites and predators
    - How many parasites and predators HDF will release
    - How HDF will prevent the accidental release of Invasive Species
    - What is the effectiveness of the parasites and predators
    - What pests will the parasites and predators target
    - What are the impacts on non-target species

  - The DEIS fails to describe how fly parasites will be integrated into HDF pest control.

  - The DEIS fails to provide an analysis of the amount of pest fly control HDF expects to achieve with predators, and does not provide sufficient information about the source of pest fly predators, when they will be released, and how HDF will prevent the accidental release of Invasive Species.

- The DEIS fails to provide enough information about the HDF biological control methods that would be part of an IPM plan, monitoring plan, or Best Management Practices plan.

Dung Beetles

HDF is relying on dung beetles to reduce pest flies and accumulated manure.

Dung-Dwelling Beetles known from Kaua'i

Aphodius lividus (Olivier)
Copris incertus Say
Oniticellus militaris (Castelnau)
Onthophagus gazella (Fabricius)
Sphaeridium scarabaeoides (Linnaeus)

- **Effectiveness**

  - The DEIS proposes that HDF will use dung beetles to hasten the breakdown of manure, and to minimize pest fly populations, but provides no analysis of the amount of manure a dung beetle consumes.

  - The DEIS states that a healthy population of dung beetles can bury a dung pat in one to three days. The DEIS provides no references or evidence to support this claim.

Soil Types and Conditions

- The DEIS fails consider how HDF clay soils will impact dung beetle dung-burying capacity.

- The DEIS does not analyze the effects of excessive soil moisture on dung beetle dung-burying capacity.

- The DEIS neglects to consider what impacts the paddock rotation schedule could have on dung beetles.

Competition for Food and Nesting Sites

- The DEIS does not take into account how competition for both food and nesting space in adult and larval dung beetles may impact dung beetle manure burying capacity.

Dung Beetle predators

- The DEIS did not consider the potential impacts predators may have on dung beetle establishment and effectiveness at controlling pest flies or the massive amount of manure that would be generated by HDF dairy cows.

Controlling Pest Flies

- The DEIS claims that dung beetles will reduce pest fly populations by 95%. This claim is contradicted by their own manure-related arthropod survey. Both dung beetles (*Onthophagus gazella*), and the biting stable fly were found to be abundant during the survey.

- It is unlikely that HDF will achieve significant pest fly control with dung beetles. The DEIS does not provide an IPM plan that fully describes how pest flies would be controlled.

➢ **Translocation of Dung Beetles**

- The DEIS states that deploying a night collection light and white sheet can collect many adult dung beetles to quickly boost the population at HDF. The DEIS fails quantify the number of dung beetles that would be collected with these traps, and fails to describe the collection locations.

- Up to 8 million actively feeding adult dung beetles could be required on any given day to effectively suppress fly development. The DEIS neglects to provide sufficient information about how many dung beetles would be translocated and how they intend to capture the large numbers of dung beetles necessary to control pest flies and process manure pats.

- The DEIS fails to consider the accidental release of pest species collected with the dung beetles.

- ✯ The DEIS does not address:

  - The possibility of translocating invasive species
  - Who will collect the dung beetles to be translocated
  - How will insect species other than dung beetles be removed from the collections before transport
  - What methods will HDF employ to ensure survival of the translocated species during transport

- ✯ The DEIS fails to consider that dung beetles may become a nuisance pest on nearby properties.

Hawaiian Native, Threatened, and Endangered Species

- **Endangered Arthropod Species**

  - ✯ The DEIS states there are no native, protected, or endangered insect species within the HDF site, however, HDF failed to perform a complete arthropod survey and assessment, and did not provide complete information about potential impacts on Kauai's endangered cave arthropods.

  - ✯ The DEIS did not fully consider potential impacts to Kauai's endangered cave arthropods.

- **Kaua'i Forest Birds**

There is a potential for mosquito populations to increase at HDF.

- ✯ The DEIS fails to discuss potential impacts to endangered Hawaiian forest birds by mosquitoes.

- **Native Insects**

Only sixteen arthropod species were identified in the manure-related arthropod survey. A study of a similar landscape less than 15 miles from HDF identified 238 insect species, about 10% of which were native Hawaiian species.

- ✯ The DEIS did not conduct a standard arthropod survey and assessment.

- ✯ The manure-related arthropod study was not sufficient to inform the public about all potential arthropod species that occur at the HDF site.

II. INTRODUCTION

Hawai‘i Dairy Farms (HDF) proposes to establish a dairy farm on 557 acres of agricultural land in Māhā‘ulepū Valley on the island of Kaua‘i. HDF would initially establish a herd of 699 mature dairy cows, and 150 calves with additional cows located on other existing Kaua‘i ranches. The average dairy cow produces up to 2.3 cu. ft. of manure per day (HDF Waste Management Plan), thus the 699 dairy cows at HDF could produce up to 1,608 cu. ft. of manure per day. That is equivalent to six large dump truck loads of manure per day, not including the manure from the 150 calves. This large amount of manure would be breeding habitat for pest flies which are capable of migrating from HDF to surrounding properties on Kaua‘i.

A draft environmental impact statement (DEIS) was prepared by HDF to analyze the potential environmental impacts and mitigation measures associated with dairy operations. The DEIS was released on June 8, 2016 and is undergoing a 45-day agency and public review. Pacific Analytics, LLC performed a review of the arthropod-related sections of the DEIS. The information provided in the DEIS was evaluated for completeness and the analyses were assessed for potential flaws.

This evaluation consists of four major sections

- Pest Flies
- Pest Control
- Dung Beetles
- Hawaiian Native, Threatened and Endangered Species.

III. DISCUSSION

Pest Flies

The DEIS mentions six species of pest flies (DEIS page 4-39), but fails to mention four other species of pest flies that occur on Kaua‘i[1, 2]. All of these species breed in manure[2] and are very likely to breed at HDF. The DEIS states that there will be no impact due to 699 cows (DEIS page 4-101), but fails to address the impacts of significant amounts of manure and the number of pest flies that will breed in that manure. The DEIS states that qualitative or quantitative analyses were conducted for pest species (DEIS pages 4-79 and 4-97), but fails to include those analyses for public comment.

Fly Species from Dairies Identified in *An Evaluation of Fly Breeding and Fly Parasites at Animal Farms on Leeward and Central O‘ahu*[2]

- *Stomoxys calcitrans* (Linnaeus) – Stable Fly
- *Haematobia irritans* Linnaeus – Horn Fly
- *Musca sorbens* Wiedemann – Dog Dung Fly
- *Musca domestica* Linnaeus – House Fly
- *Hydrotaea chalcogaster* (Wiedemann) – Small Blue Fly
- *Tricharea occidua* (Fab.) – Flesh Fly
- *Ravinia anxia* Walker – Flesh Fly
- *Ornidia obesa* (Fabricius) – Green Hover Fly
- *Eristalis arvorum* (Fabricius) – Hover Fly
- *Hermetia illucens* (Linnaeus) – Black Soldier Fly

➢ Biting Flies

There are two species of biting flies associated with dairies, the stable fly and the horn fly[2].

The Stable Fly - *Stomoxys calcitrans* (Linnaeus)

Stable Fly - *Stomoxys calcitrans*

- Stable flies are active year-round in warm latitudes
- Their highest fecundity is during warm, wet summers[5, 6, 7]
- Stable flies oviposit an average of 500 eggs over their two week life span.
- Eggs hatch in 15–24 hours under favorable conditions, and hatching rates are greatest between 25°C and 35°C
- Larvae develop in manure and moist, decaying vegetation
- Larvae also live in substrates with active microbial communities including wet grass and thatch[8]
- The larvae burrow into the dung as the surface layers dry out and larvae growth is usually completed in 4–5 days
- Pupation takes place in or under the dung pats, and adults emerge in 3–5 days under ideal conditions
- Both sexes require blood meal for mating[9]
- Can disperse regularly up to 6.5 km (4 miles)[10, 11, 12, 13]
- Known to disperse up to 225 km (140 miles) when wind blown[3]

The Horn Fly - *Haematobia irritans* Linnaeus

Horn Fly - *Haematobia irritans*

- A serious pest of cattle in Hawai‘i[2, 14]
- Numerous natural enemies and competitors have been imported to Hawai‘i for its control[2, 14]
- The primary breeding medium is wet manure[2]
- Females lay up to 500 eggs
- Both sexes require blood meal up to 30 times a day
- Can disperse up to 11 km (~7 miles)[4]

❖ Biting Fly Dispersal

The DEIS fails to discuss the dispersal capability of biting flies to other properties on Kaua‘i. Both species of biting flies known on Kaua‘i are strong fliers and can migrate long distances driven by wind[3, 4]. In Florida, large swarms of stable flies are driven by winds to coastal beaches from dairies up to 225 km (140 miles) away[3]. Stable flies have been shown to disperse 6.5 km (4 miles) along a beach in 30 minutes, pushed by a 5- to 8-kph wind[10]. Figure 1 illustrates these distances superimposed on a map of Po‘ipū on Kaua‘i. The map does not account for overland contours, but instead provides an illustration of the dispersal capabilities of the stable fly.

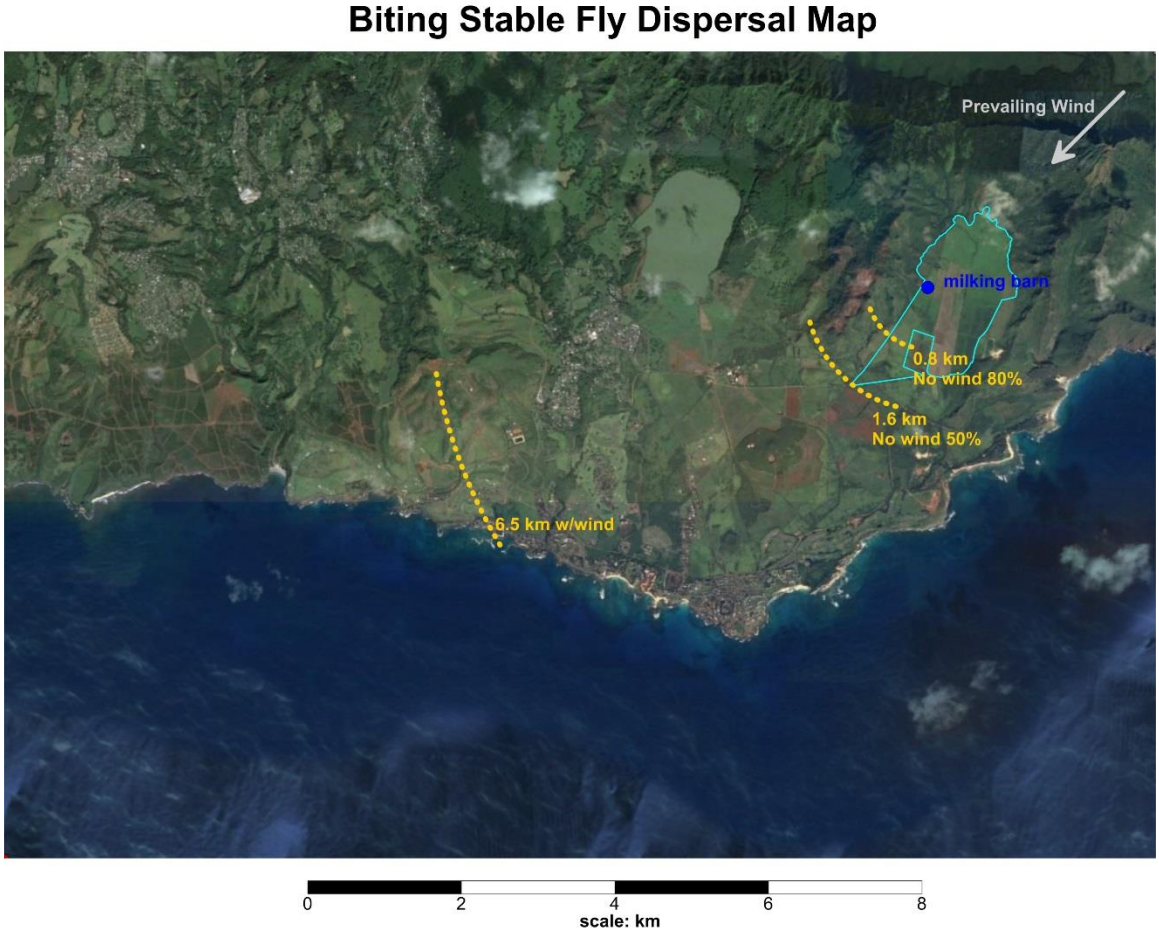


Figure 1. Map of Po‘ipū, Kaua‘i showing dispersal capability of the stable fly. With no wind, 80% of the biting stable flies would disperse at least 0.8 km from the milking parlor, and 50% would disperse at least 1.6 km. With a 5 to 8-kph wind, biting stable flies can disperse up to 6.5 km[10].

Horn flies emerging from manure would disperse 1.7 km (1 mile) from a paddock without a change in density[4]. Researchers found while monitoring a herd of dairy cows, that horn flies flew 11 km (7.3 miles) or more in less than 10 hours[4]. Figure 2 illustrates these distances superimposed on a map of Po'ipū on Kaua'i. The map does not account for overland contours, but instead provides an illustration of the dispersal capabilities of the horn fly.

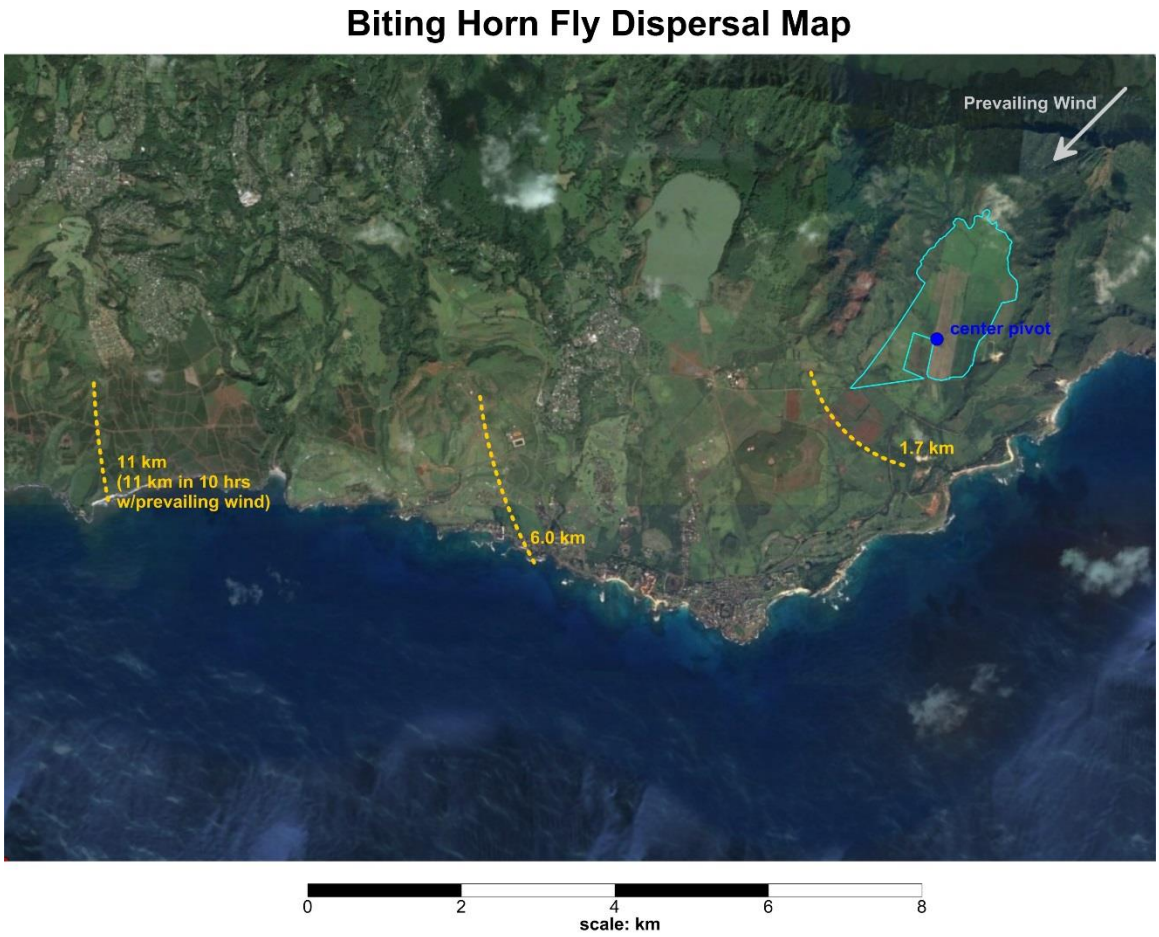


Figure 2. Map of Po'ipū, Kaua'i showing dispersal capability of the horn fly. With no wind, horn flies will move up to 1.7 km with the same density as found in a paddock. With the prevailing wind, horn flies can disperse up to 11 km in ten hours[4].

➢ Nuisance Flies

There are at least six species of nuisance flies on Kaua‘i[1, 2]. The species originating from dairies which cause the most complaints from properties near dairies are the dog dung fly and house fly[2]. The DEIS fails to evaluate the potential impacts of nuisance flies on nearby properties on Kaua‘i.

The Dog Dung Fly - *Musca sorbens* Wiedemann

- Larvae feed on all sorts of dung
- Adults feed on food, garbage, and filth
- Adults are particularly aggressive and can be extremely unpleasant when they occur in large numbers[16].
- Attracted to eyes, open sores, and wounds

Dog Dung Fly - *Musca sorbens*

The House Fly – *Musca domestica* Linnaeus

- Closely associated with humans
- One of the fastest breeding insects in Hawai‘i. Adult house flies can lay up to 900 eggs in 4 to 12 days[16]
- Larvae feed on excrement and garbage, and mature in as little as 6 days
- Will disperse up to 10 km (6.2 miles) in 24 hr[17]

House Fly - *Musca domestica*

Other flies can become a nuisance when they aggregate near human habitations. These pests include the small blue fly, flesh flies, and hover flies. Annoying in small numbers, nuisance flies become irritating or can spread diseases as their numbers increase. The DEIS fails to assess nuisance flies and their impacts on nearby properties.

Small Blue Fly - *Hydrotaea chalcogaster* (Wiedemann)

- Also known as garbage flies
- Larvae develop in manure, garbage, and decaying vegetation
- Adults often hover in shafts of light
- Attracted to various substances including sugar, sweat, and blood

Small Blue Fly – *Hydrotaea chalcogaster*

Flesh Flies - *Tricharea occidua* (Fabricius) and *Ravinia anxia* Walker

- Attracted to open wounds
- Larvae develop in manure and decaying vegetation
- Females are viviparous, they deposit live larvae instead of eggs
- Nuisance pest around humans

Flesh Fly - *Tricharea occidua*

Flesh Fly - *Ravinia anxia*

Green Hover Fly - *Ornidia obesa* (Fabricius)

- Breeds in decomposing vegetation, semi-liquid manure and urine polluted areas
- Carry bacteria of health importance
- Larvae reach their full development in 25 days

Green Hover Fly - *Ornidia obesa*

- **Mosquitoes**

Mosquitoes are not dung-dwelling flies, but the proposed dairy could potentially generate large populations of these pests in standing water, ponds, ditches, and pasture divots. Mosquitoes would be blown by the prevailing winds from HDF and descend on nearby properties. There are four species of mosquitoes on Kaua‘i capable of breeding at HDF[1].

Yellow Fever mosquito - *Aedes aegypti*

The Hawai‘i Department of Health[18] warns that two of the species on Kaua‘i, The Yellow Fever mosquito (*Aedes aegypti*) and the Asian tiger mosquito (*A. albopictus*) can transmit viruses that cause dengue fever and Zika virus disease. The Southern House mosquito, (*Culex quinquefasciatus*) is a nuisance to humans, but is a vector for avian malaria and avian pox. These mosquito-borne diseases have already devastated Hawaiian honeycreepers, leading some species to extinction[23, 24, 25]. The DEIS does not mention mosquitoes, and includes no analysis of the potential impacts by mosquitoes on HDF neighbors or native Hawaiian endangered birds.

Pest Control

- **Integrated Pest Management (IPM)**

The DEIS states in several places that HDF will use Integrated Pest Management (IPM) measures and an IPM program to control pest flies at the dairy (DEIS pages 1-14, 1-15, 4-41, 4-42, 4-44, 4-45, 4-80, 4-97, 4-101, 4-105, 6-20), however, the DEIS does not provide an actual IPM plan or details of how various control measures would be integrated.

An Integrated Pest Management Plan has several components, including:

- Clearly stated goals and objectives that would be achieved by implementing the plan
- A Monitoring Plan for pest populations and other relevant factors
- A determination of the thresholds for various pest populations that trigger treatments
- A detailed description of each control method that would be used
- A explanation of how treatments would be selected for deployment, which would be used, and when they would be used, including details about timing treatments for maximum effectiveness
- How the effectiveness of treatments would be evaluated
- An account of how biological controls would be conserved and enhanced

While the DEIS mentions some measures HDF would take to control pests, it does not describe how those measures would be integrated into an effective program.

The DEIS also states HDF would use Best Management Practices to control pests, but fails to provide a Best Management Practices plan.

- **Chemical Controls**

The DEIS states that HDF will use chemical methods to prevent any spike in pest populations (DEIS page 4-41), but fails to mention:

- Which chemicals will be used
- What the thresholds are for chemical application decision-making
- What quantities chemicals will be applied
- Where the chemicals will be applied
- Which pests the chemicals will target

This information would be found in an IPM plan. The DEIS does not provide an IPM plan.

The DEIS neglects to address the effectiveness of chemical controls on target species. Chemical control of some pest species, such as stable flies, has been unsuccessful[5], and other pest species, such as horn flies and house flies, have developed resistance to chemical controls[22, 23, 24, 25, 26, 27].

The DEIS fails to consider impacts of chemical control on dung beetles and other non-target arthropods. Pest fly insecticides are toxic to exotic dung beetles and native arthropod species[28, 29]. Veterinary pharmaceuticals have also been found to have adverse impacts to dung beetles[30, 31, 32, 33, 34, 35, 36]. Chemicals applied for pest fly control destroy dung beetles and parasite control measures, and can lead to outbreaks of pest flies. The DEIS fails to describe how non-target impacts of chemical control will be avoided.

The DEIS fails to provide any information about chemical control of mosquitoes.

- **Mechanical Control**

The DEIS states that mechanical methods, such as sticky tapes or ribbons and traps, will be used to prevent spikes in pest populations (DEIS page 4-41). The DEIS provides no details about:

- The types of mechanical devices to be deployed
- The number of mechanical devices to be deployed
- Where mechanical devices will be deployed
- How long mechanical devices will be deployed
- The effectiveness of the mechanical devices
- What constitutes a "spike" in pest populations and how they would be detected

The DEIS neglects to discuss the effectiveness of mechanical devices HDF will deploy. Walk-through horn fly traps have been shown to be only 57% effective[37] leaving a significant quantity of flies free to multiply. Sticky-traps are only 5.6% to 14% effective[38] and baited traps are only slightly better, capturing only 4.4% to 20% of released flies in controlled experiments[39]. The effectiveness of traps depends on several factors, including temperature, season and position[40]. The DEIS does not provide sufficient information about deployment of traps to determine if their use will be effective. The DEIS provides no information about mechanical control of mosquitoes.

- **Parasites and Predators**

The DEIS states that HDF proposes to release insect parasites and predators to control fly populations (DEIS pages 4-39, 4-45, 4-80), but fails to provide information about:

- What fly parasite and predator species will be used at HDF
- What is the source of parasites and predators
- How many parasites and predators will HDF release
- How HDF will prevent the accidental release of Invasive Species
- What is the effectiveness of the parasites and predators
- What pests will the parasites and predators target
- What are the impacts on non-target species

There have been eight parasites of horn fly purposely released for biocontrol in Hawai'i[41] and only one established on Kaua'i[1]. Nine parasites have been purposely released in Hawai'i to control house flies[41] and only one established a population on Kaua'i[1]. The reference cited by DEIS regarding stable fly control effectiveness (DEIS page 4-39) contains no evidence that parasites control flies. The DEIS fails to describe how fly parasites will be integrated into HDF pest control.

Twelve predators have been purposely released for biological control of the horn fly in Hawai'i, only three of which established on Kaua'i [1, 41]. Researchers studying predators associated with flies in animal dung on O'ahu [2] discovered that fly predators have difficulty locating their fly prey and are not effective horn fly biological control. Other studies have also demonstrated the inefficiency of fly predators in finding their prey[42, 43]. The DEIS fails to provide an analysis of the amount of pest fly control HDF expects to achieve with predators, and does not provide sufficient information about the source of pest fly

predators, when they will be released, and how HDF will prevent the accidental release of Invasive Species.

Studies have demonstrated that when pesticides are applied to fly larvae at their breeding sites, almost 100% of the natural enemies, both parasites and predators, are destroyed[39, 44]. The DEIS fails to provide enough information about the HDF biological control methods that would be part of an IPM plan, monitoring plan, or Best Management Practices plan.

Dung Beetles

HDF is relying on dung beetles to reduce pest flies and accumulated manure (DEIS pages 1-15, 3-23, 4-39, 4-41, 4-42, 4-45, 4-80, 4-97, 4-105, 6-20). During the manure-related arthropod survey (DEIS Appendix B), there were two dung beetle species found near the HDF site. Despite the purposeful release of twenty-nine dung beetles in Hawai‘i[39, 45], only five are found on Kaua‘i[1].

Dung-Dwelling Beetles known from Kaua‘i

Aphodius lividus (Olivier)
Copris incertus Say
Oniticellus militaris (Castelnau)
Onthophagus gazella (Fabricius)
Sphaeridium scarabaeoides (Linnaeus)

Aphodius lividus (Olivier)

- 3 to 6 mm (less than ¼ inch)
- Females produce up to 100 eggs in their adult lifetime of 1 to 2 months[46]
- Females lay eggs singly or in small clutches[46]
- Dung Dweller, Adults and larvae live in dung [46]
- Larvae take up to six weeks to develop[45]
- Consume a small fraction of material in dung pat[47]
- Known to inhabit and destroy other dung beetle brood chambers[48]
- Accidental introduction to Hawai‘i[1]

Aphodius lividus

Copris incertus Say – **Mexican Dung Beetle**

- 15 to 17 mm (a little more than ½ inch)
- Feed on microbes in liquid manure
- 6 weeks to completely breakdown dung pat[49]
- Not efficient at controlling pest flies[49]
- Dung Burrower, adults live in manure and form brood chambers in the soil where larvae develop[50]
- A purposeful introduction to Hawai'i (1922)[1, 39]

Copris incertus

Oniticellus militaris (Castelnau)

- 7 to 11 mm (¼ to ½ inch)
- Feed on microbes in liquid manure
- Tunneler 0-15 cm (0-6 inches) deep[51]
- Active during warm, wet weather
- A purposeful introduction to Hawai'i (1957)[1, 39]

Oniticellus militaris

Onthophagus gazella (Fabricius)

- 10 to 13 mm (½ inch)
- Feed on microbes in moist manure
- Prefers firm to semi-liquid dung pats
- Prefers moist, loose soil[52]
- Burrows 20 to 25 cm (8-10 inches) deep[52]
- 6 to 8 weeks egg to adult
- A purposeful introduction to Hawai'i (1957 and 1973)[1, 39]

Onthophagus gazella

Sphaeridium scarabaeoides (Linnaeus) - **Water Scavenger Beetle**

- 5.0 to 7.0 mm (< ¼ inch)
- Adults and larvae feed in cow manure
- Larvae eat fly eggs and larvae, and beetle larvae in manure[53]
- An accidental introduction to Hawai‘i[1]

Sphaeridium scarabaeoides

➢ **Effectiveness**

The DEIS proposes that HDF will use dung beetles to hasten the breakdown of manure, and to minimize pest fly populations (DEIS pages 1-15, 3-24, 4-41, 4-42, 4-80, 4-97, 4-105, 6-20, Appendix B pages 1, 2, 22, 29, 30, 31), but provides no analysis of the amount of manure a dung beetle consumes.

The DEIS states that a healthy population of dung beetles can bury a dung pat in one to three days (DEIS pages 3-24, 4-41, 4-42). The DEIS provides no references or evidence to support this claim. In an extensive field study up to 80% of the dung remained unburied after seven days[58].

Removing Manure from the Soil Surface

There are several reasons why dung beetles may not fully bury manure pats, including:

- Dung Beetle nesting biology
- Soil types and conditions
- Competition for food and nesting sites
- Fluctuations in dung beetle populations
- Dung Beetle predators
- The large quantity of manure generated by 699 dairy cows
- The even larger quantity of manure generated by 2,000 dairy cows

❖ Dung Beetle Nesting Biology

Dung beetles do not feed their entire adult life. After an initial feeding period, adults (males and females) remain inside the nesting galleries made under the soil surface[59]. Adult dung beetles stay in the nest taking care of the brood balls throughout embryonic, larval and pupal development, leaving shortly before or when progeny emerge[60, 61]. This reduces the feeding efficiency of adult dung beetles, and increases the number of dung beetles required to consume large quantities of manure.

❖ Soil Types and Conditions

The DEIS fails to consider how HDF clay soils will impact dung beetle dung-burying capacity. The most abundant soil types occurring throughout the HDF site are Kalihi Clay and Ka'ena Clay Brown Variant, accounting for more than 60% of the area (DEIS page 4-8). The rest of the soils at HDF are other types of clay (about 30% of the area) and clay loam (about 10% of the area). Dung beetles are less efficient burying dung pats on clay soils than on sandy soils[62, 63, 64, 65, 66] and more dung beetle species prefer sandy soil habitats to clay soil habitats[62]. *Onthophagus gazella*, the most abundant dung beetle at the proposed HDF location, usually buries pats on sand or sandy soils rather than on heavier soil types[55].

The DEIS does not analyze the effects of excessive soil moisture on dung beetle dung-burying capacity. Soil moisture contributes to dung beetle breeding success as well. Soils that are too wet will support fewer dung beetles than drier soils[67, 68]. Excess moisture results in higher mortality of dung beetle eggs and larvae in the top 10 cm of the soil beneath dung pads[69, 70, 71]. HDF clay soils will likely be saturated or nearly saturated most of the year, due to rainfall patterns and irrigation that spreads liquid manure from wash-down in the HDF milking parlors[72]. This water could flood dung beetle nesting burrows, drowning the larvae and adults guarding the nesting burrows. Poorly drained clay soil promotes larvae-killing mold and fungi that could cause dung beetles to fail to establish at HDF[75].

Cattle easily damage moist clay soil, creating divots and ruts. A herd of 100 dairy cows or more grazing a three acre paddock could trample dung beetle brood nests. Dung beetle larvae take several weeks to months to develop, and pupae often diapause underground until conditions are right for their emergence, subjecting the immature dung beetles to disturbance every 18 days by rotational-grazing cattle. The DEIS neglects to consider what impacts the paddock rotation schedule could have on dung beetles.

❖ Competition for Food and Nesting Sites

The DEIS does not take into account how competition for both food and nesting space in adult and larval dung beetles may impact dung beetle manure burying capacity. For tunnelers, like *O. gazella*, there is competition between adults for food in the dung pat and for nesting space below the dung pat[49]. And at higher dung beetle densities there is usually a lower degree of burial than would be expected, due to mutual interferences[56, 58, 74, 76].

❖ Dung Beetle predators

The potential for dung beetles to bury significant quantities of manure may be limited by dung beetle predators. The faunal report attached to the DEIS (Appendix A) lists several species of birds, many of which are insectivores, including the cattle egrets (*Bubulcus ibis*), Plovers (*Pluvialis filva*), the Myna (*Acridotheres tristis*), and barn owls (*Tyto alba*). These birds or similar species have been observed eating dung beetles in pastures[68, 75, 77] and may be responsible for large amounts manure being left above ground[56].

Cane toads at the proposed HDF site eat dung beetles. Studies have found as many as 80 dung beetles in a single cane toad preying next to cow manure[78, 79]. Predation on dung beetles by cane toads around dung pats reduces the number of dung beetles enough to substantially influence dung pat breakdown[75]. The DEIS did not consider the potential impacts predators may have on dung beetle establishment and effectiveness at controlling pest flies or the massive amount of manure that would be generated by dairy cows.

❖ Controlling Pest Flies

The DEIS claims that dung beetles will reduce pest fly populations by 95% (DEIS page 4-39, Appendix B page 30). This claim is contradicted by their own manure-related arthropod survey. Dung beetles (*Onthophagus gazella*), and biting stable flies were both found to be abundant during the survey. The claim of "95% control" is from a laboratory experiment[55] and does not represent what could occur under actual field conditions. A field study investigating the control of horn flies by dung beetles found the carrying capacity of each day's excreta was about 20,000 horn flies per cow[80]. That amounts to almost 14 million horn fly larvae per day for the 699 initial herd size daily. The study found that the presence of 50 pairs of the dung beetle *O. gazella* per kg of manure would result in a 50% mortality to horn fly larvae, leaving about 10,000 viable larvae per cow per day, (6,990,000 viable horn fly larvae per day), and would have little effect on adult horn fly populations. They concluded that the effect of dung beetles in removing pest fly larval habitat would be relatively small[80].

Of these numerous biocontrol species introduced to control horn flies in Hawai'i[16, 39] only eight are found on Kaua'i [44]. Even with the release of these beneficial insects, the horn fly continues to be a serious pest in Hawai'i[81].

There are two reasons why dung beetles have not effectively controlled horn flies on Kaua'i First, the dung beetle *Oniticellus militaris* does not dispose of manure swiftly enough to have an appreciable impact on horn fly survival. Horn fly eggs hatch quickly, and larvae pupate under the manure, avoiding disturbance by beetles[82]. Secondly, horn flies oviposit whenever suitable manure is present, whereas most dung beetles fly at night to find a suitable dung pat to exploit [82]. This gives the flies a competitive advantage. Horn fly eggs hatch within hours and larvae start developing, but control is effective when only eggs are present[81].

It is unlikely that HDF will achieve significant pest fly control with dung beetles. The DEIS does not provide an IPM plan that fully describes how pest flies would be controlled.

- **Translocation of Dung Beetles**

HDF intends to translocate dung beetles from elsewhere on Kaua'i or, working with State Department of Agriculture to translocate beetles from other Hawaiian islands (DEIS pages 1-15, 4-42, 4-81, Appendix B pages 2, 29, 30, 31). The DEIS neglects to analyze the impacts of depleting dung beetle populations on or near the collection properties.

The DEIS states that deploying a night collection light and white sheet can collect many adult dung beetles to quickly boost the population at HDF (DEIS page 4-40, Appendix B page 29). The DEIS fails quantify the number of dung beetles that would be collected with these traps. It is unlikely that translocation of dung beetles from other areas on Kaua'i will provide a sufficient number of dung beetles capable of immediately controlling manure-related flies. Biological control experience with dung beetles found that beetle populations did not increase rapidly and disperse until up to 10 years after mass release[28, 54].

A dairy cow produces up to 2.3 cu. ft. (~28 l) of manure per day (HDF Waste Management Plan), thus six hundred and ninety-nine dairy cows can produce about 1,608 cu. ft. (19,572 l) of manure per day. Under laboratory conditions it requires 840 pairs of dung beetles (*Onthophagus gazella*) per cu. ft. to effectively suppress the development of horn flies for the volume of manure from 699 dairy cows[55]. It is estimated that it would require about 2.7 million actively feeding adult dung beetles on any given day to effectively suppress horn

fly development under laboratory conditions. Under field conditions on Kaua'i, even more dung beetles could be required to effectively suppress development of fly larvae. Even when a large number of dung beetles are present, soil type and mutual interference can lower the manure-burying capacity of dung beetles and thereby reduce the effectiveness of fly control[56]. It is not reasonable to expect HDF to be able to capture and translocate 2.7 million dung beetles on Kaua'i. If 2,000 cows are at HDF, then 8 million actively feeding adult dung beetles could be required on any given day to effectively suppress fly development under laboratory conditions[56]. The DEIS neglects to provide sufficient information about how many dung beetles would be translocated and how they intend to capture the large numbers of dung beetles necessary to control pest flies and process manure pats.

The DEIS fails to consider the accidental release of pest species collected with the dung beetles. Many species of insects are attracted to lights at night, and will gather on the collecting sheets. Dung beetles are less than 10 mm (½ inch) long and some pest species in the same family (Scarabaeidae) look similar to dung beetles on the collecting sheets at night. For example, the Chinese Rose beetle (*Adoretus sinicus* Burmeister), a serious pest of over 500 native and landscape plants in Hawai'i, is about the same size as dung beetles found on Kaua'i. The accidental collection and relocation of pest beetle species to HDF could result in migration to nearby golf courses and landscaping. Adult dung beetles are potential carriers of rhabditic and helminthic worms and other organisms (including phoretic mites), and scientists recommend that only dung beetle eggs can be translocated in order to prevent worm contamination[57]. The DEIS does not address:

- The possibility of translocating invasive species
- Who will collect the dung beetles to be translocated
- How will insect species other than dung beetles be removed from the collections before transport
- What methods will HDF employ to ensure survival of the translocated species during transport

The DEIS fails to consider that dung beetles may become a nuisance pest on nearby properties. Dung beetles are attracted to lights and even if a portion of the millions of dung beetles HDF hopes to have at the dairy are attracted to lights at resorts and homes near the dairy the beetles could be bothersome.

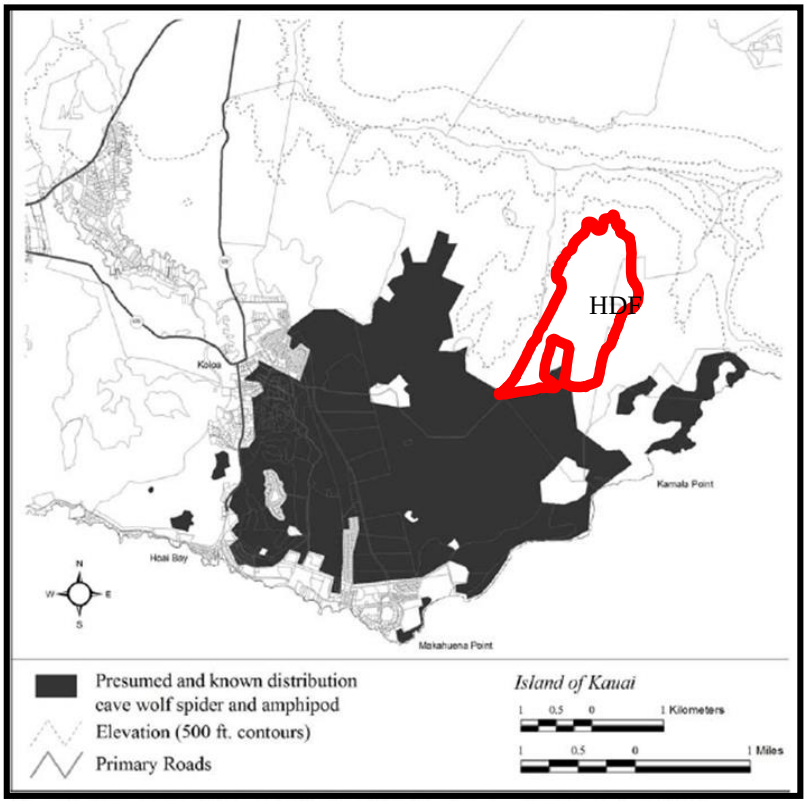
Hawaiian Native, Threatened, and Endangered Species

➢ Endangered Species

The DEIS states there are no native, protected, or endangered insect species within the proposed HDF site (DEIS page 4-40, Appendix B page 12-13), however, HDF failed to perform a complete arthropod survey and assessment, and did not consider impacts information about Kauai's endangered cave arthropods.

❖ Cave Arthropods

The DEIS fails to analyze potential impacts to endangered arthropod species. There are two species of endangered cave arthropods on Kaua‘i, the Kaua‘i Cave Wolf Spider (*Adelocosa anops* Gertsch) and the Kaua‘i Cave Amphipod (*Spelaeorchestia koloana*). These unusual animals are known only from caves, subterranean cracks, and microcaverns (voids and inaccessible passages) in Koloa District on Kaua‘i[83].



Presumed and known distribution of the Kaua‘i cave wolf spider and amphipod.[83]

Potential threats to Kauai's Endangered Cave Arthropods[82]

- Pesticides
- Non-Native Invasive Species
- Habitat disturbance
- Altered humidity levels
- Insufficient food source
- Contaminants in ground water

The cave wolf spider is an opportunistic predator, feeding on whatever prey it can find. The cave amphipod is a detritivore, feeding on roots and decaying vegetation. Its food source can be disturbed by altering the vegetation above the habitat[83].

The DEIS states there is no evidence of lava tubes or caves at the HDF site and that no such features have been reported nearby (DEIS page 4-42, Appendix B pages 2 and 20), yet it acknowledged that there are caves within 0.75 miles of the proposed dairy (DEIS page 4-40). One of these is within the Makauwahi Cave Reserve, where Kauai's endangered cave arthropods have been observed[82].

Habitat for these cave arthropods is not exclusively large caves that can be detected by wandering haphazard transects across proposed HDF pastures. Interstitial spaces and cracks form in lava as it cools, resulting in an interconnected system of voids up to 20 km long[84]. The small spaces are known as microcavernous habitat.

Hawaiian troglobitic arthropods live in suitable spaces in both the microcavernous habitats and in the larger cave habitats[84]. While the principal habitat for most cave-dwelling species is in spaces 0.5 to 10 cm, cave species can disperse through microcavernous spaces[85, 86, 87, 88].

It is likely the lava tube system below HDF is connected to the cave habitat of these two endangered species[89]. Herbicides and pesticides and other ground-water contaminants that will be applied at HDF may migrate to microcavernous habitat and impact the endangered species there. These cave animals are particularly vulnerable to pesticides and contaminants because of their affinity for moisture[85] and because the exoskeleton of the Hawaiian cave organisms is permeable to water[90]. Even when pesticides are not used directly above a lava tube, pesticides can leach into the microcavernous habitat, exposing the species to additional risk via absorption of contaminants through their exoskeleton[91].

Even if not killed outright, sublethal effects of pesticides on the cave animals could reduce fecundity and life span, slow development, and impair mobility and feeding efficiency[92].

The DEIS also failed to disclose the impacts to Kauai's endangered cave arthropods from pharmaceuticals typically used by dairies, including antibiotics, anthelmintics, and parasiticides. HDF failed to reveal the half-life of these chemicals, and the persistent impacts they may cause, especially to Kauai's endangered cave arthropods. These pharmaceuticals may leach into ground-water and find their way to underground cave arthropod habitats.

- **Kaua'i Forest Birds**

The DEIS fails to discuss potential impacts to endangered Hawaiian forest birds by mosquitoes. There is a potential for mosquito populations to increase at HDF. Moist ground around troughs and in paddocks often become roughened by cattle hooves, producing myriad small pockets of water where mosquitoes can multiply[93]. Dairy waste water in ponds and slow moving waterways can be havens for mosquitoes[94]. The DEIS neglects to address control measures for mosquitoes at HDF.

Mosquitoes are not only a problem for humans, annoying us while they seek to extract a blood meal, they are also a serious problem for Hawaii's famous forest birds. Mosquitoes carry avian malaria that has caused a number of extinctions, population declines, and range contractions of native birds in Hawai'i[95]. Uncontrolled at HDF, mosquitoes can multiply rapidly and migrate to bird nearby upland habitats where they can infect these threatened and endangered species.

Partial List of Hawaiian Native Forest Birds on Kaua'i[95]

Common Name	Scientific Name
Puaiohi	*Myadestes palmeri*
'Akeke'e	*Loxops caeruleirostris*
'Akikiki	*Oreomystis bairdi*
'Anianiau	*Hemignathus parvus*
'Apapane	*Himatione sanguinea*
'Elepaio	*Chasiempis sandwichensis sclateri*
'I'iwi	*Vestiaria coccinea*
Kaua'i 'Amakihi	*Hemignathus Kauaiensis*

- **Native Insects**

The DEIS did not conduct a standard arthropod survey and assessment. The manure-related arthropod study was not sufficient to inform the public about all potential arthropod species that occur at the HDF site. According to the report (DEIS Appendix B):

- The primary purpose of the survey was to determine the presence or absence of species associated with the manure of cattle and of the parasites and predators that control them.
- The major focus of the survey was on the fresh and dry manure generated by beef cattle at the adjacent pasture for Māhā‘ulepū Cattle Co.
- No attempt was made to document endemic and indigenous Hawaiian invertebrate species, although they were reported when seen.

Only sixteen arthropod species were identified in the manure-related arthropod survey. A study of a similar landscape less than 15 miles from HDF identified 238 insect species, about 10% of which were native Hawaiian species[96]. A complete and thorough arthropod survey is required to fully assess the impacts of the project on the existing arthropod fauna.

V. CONCLUSIONS

The Hawai‘i Dairy Farms Draft Environmental Impact Statement did not fully analyze the arthropod-related impacts of dairy operations on nearby properties. It failed to discuss all the pest flies and the potential impacts of the increase in their populations that will result from manure generated by dairy cows.

The DEIS neglected to provide sufficient information about the control of the biting and nuisance flies, and failed to provide an Integrated Pest Management plan, depriving the public of the opportunity to properly evaluate the impacts of the dairy's operation. Insufficient information was provided in the DEIS regarding chemicals that would be applied at HDF, the kinds of mechanical devices that would be deployed for pest fly control, and the species and source of parasites or predators that may be released. HDF failed to consider the accidental release of landscape and turf pests when translocating dung beetles, and other associated concerns with invasive species.

The DEIS did not fully consider the difficulties associated with dung beetle biological control of manure and manure-related arthropod pests. Dung beetle species are unevenly distributed throughout their ranges. Their occurrence, activity, and abundance is influenced by soil and vegetation type, and by seasonal variations in temperature and rainfall. The current distribution of dung beetles on Kaua‘i is not known and there are no published data on their population densities and little on the effect that any of these insects has on dung decomposition or pest fly species in Hawai‘i. The limitations of beetle nesting biology, soil type, excessive moisture, competition for nesting, predators and the effectiveness of dung beetle control of pest flies were not analyzed in the DEIS.

The DEIS overlooked potential impacts to Hawaiian native, threatened, and endangered species on Kaua‘i. Changes to above-ground vegetation and the impacts that may have on microcavernous habitats of Kauai's endangered cave arthropods was not provided in the DEIS endangered species analysis. The potential impacts to cave-dwelling arthropods from veterinary pharmaceuticals, herbicides, and pesticides that would be used at HDF was not analyzed or discussed in the DEIS.

The DEIS failed to consider potential impacts to Kauai's forest birds by avian malaria carrying mosquitoes that would breed on HDF pastures, ponds, and waterways.

HDF did not conduct a standard arthropod survey and assessment for native, threatened, or endangered species. The manure-related arthropod study was not sufficient to analyze all potential impacts to Hawaiian native species.

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