Field Release of *Secusio extensa* (Butler) (Lepidoptera: Arctiidae), for Biological Control of Fireweed, *Senecio madagascariensis* Poiret (Asterales: Asteraceae), in Hawaii

Draft Environmental Assessment
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I. Proposed Action

An application was submitted by the Plant Pest Control Branch, Hawaii Department of Agriculture (HDOA), to the HDOA Plant Quarantine Branch, 1849 Auiki Street, Honolulu, HI 96819 for a permit to release *Secusio extensa* (Butler) (Lepidoptera: Arctiidae) into the environment of the State of Hawaii under the provisions of Hawaii Revised Statutes, Chapter 141, Department of Agriculture, and Chapter 150A, Plant and Non-Domestic Animal Quarantine. *Secusio extensa* will be used to suppress infestations of Madagascar fireweed, *Senecio madagascariensis* Poiret, a highly invasive and poisonous weed in pastures, rangelands, and wayside areas on most of the major islands, but mainly the islands of Hawaii and Maui. The caterpillars of *S. extensa* feed on the leaves of fireweed for development. Severe defoliation reduces photosynthesis and, thus, plant vigor, thereby decreasing the invasive capabilities of fireweed.

This Draft Environmental Assessment (DEA) was prepared by the applicant for the Office of Environmental Quality Control (OEQC), Department of Health, State of Hawaii, to comply with the provisions of Hawaii Revised Statutes, Chapter 343, Environmental Impact Statements.

II. Need for the Proposed Action

A. Detailed description of proposed action

Purpose of the release

The HDOA proposes to release *Secusio extensa* from quarantine containment into the natural environment of the State of Hawaii as a biological control agent to suppress infestations of Madagascar fireweed (*Senecio madagascariensis*). The release of this phytophagous insect (herbivore) is expected to contribute significantly to the suppression of fireweed infestations in Hawaii, thereby resulting in the decrease of population densities of this invasive weed statewide and greatly reducing the potential for fireweed poisoning of cattle in pastures and rangelands.

A comparison of fireweed in Hawaii with what is found in Madagascar and South Africa, the two main regions where fireweed is believed to be endemic, clearly illustrates the potential of herbivores in those native fireweed habitats to suppress populations of this weed. Under favorable conditions in Hawaii, fireweed readily disperses throughout overgrazed pastures and other disturbed sites. In Madagascar and South Africa, under similar growing conditions, only occasional plants are found.

The introduction and establishment of this moth will severely reduce the fitness of this highly invasive weed by destroying its foliage and thereby limiting its capability for photosynthesis. Repeated destruction of the leaves will eventually reduce plant vigor and, subsequently, limit flower and seed production, and thereby reduce dispersal.

Need for the release

Madagascar fireweed, commonly known as variable groundsel in Australia, has been spreading widely in the Hawaiian Islands since its first appearance around 1980. The plant competes very successfully in useful pastures and is currently invading more than 400,000 acres of valuable rangelands on the islands of Hawaii and Maui. Infestations on Oahu and Kauai have been contained by mechanical means (personal communication, Nilton Matayoshi and Becky Azama, HDOA). Infestations are so widespread on Hawaii and Maui that chemical and mechanical control is not economically feasible. Estimated chemical control of fireweed on Hawaii (Big Island) alone may exceed eleven million dollars per year for three herbicide treatments of 350,000 acres. Thus, biological control is believed to be the only effective, practical, long-term means of suppressing and limiting further dispersal of this highly invasive weed in pastures, rangelands, and wayside and natural areas.

Locations of rearing facilities and release sites

S. extensa was shipped (hand-carried) in the larval stage from Ft. Dauphin, Evatra, Madagascar and received in the HDOA Insect Containment Facility in Honolulu, Hawaii in October 1999. Specimens were regularly monitored for signs of disease and parasitoid activity but none were detected. All adult *S. extensa* that eventually emerged from rearing of the imported larvae were used to establish a quarantine colony to conduct host specificity studies to determine the suitability of this herbivore for use as a biocontrol agent to suppress infestations of fireweed in Hawaii. If and when *S. extensa* is approved for release from quarantine as a fireweed biocontrol agent, inoculative releases will commence in pastures, rangelands, and wayside areas on the islands of Hawaii and Maui, where *S. madagascariensis* is plentiful.

Number/quantity to be released

Inoculative releases of surplus progeny not needed for maintaining the propagation colony will continue to be made routinely until *S. extensa* becomes well established and widespread on Hawaii and Maui. Numbers released will depend on the success of mass production.

Timing of release

No particular timing of releases is being planned. Sites with abundant fireweed plants flushing new growth are preferred.

Method of release

During initial releases on each island, field cages will be used to contain the moths for highly concentrated egg deposition within a definitive area and to reduce the incidence of possible parasitism. As establishment of the biocontrol agent becomes evident at selected release sites, unlimited open field releases will commence.

Common name and scientific classification

Secusio extensa (Butler) (Lepidoptera: Arctiidae)

Location of voucher specimens

Voucher specimens are located at the Carnegie Museum of Natural History, Section of Invertebrate Zoology, Pittsburgh, Pennsylvania and the Hawaii Department of Agriculture, Plant Pest Control Branch, Taxonomy Unit, Honolulu, Hawaii.

B. Information on the target (host) organism

Classification of target (host) organism

According to Wagner, et al. (1990), *Senecio madagascariensis* Poiret belongs to the family Asteraceae, one of the most successful families of flowering plants. In Hawaii, this family is represented by 76 genera and 181 species distributed in 11 of the 13 tribes. There are 91 native species (90 endemic and 1 indigenous) in 12 genera. A total of 90 species in 67 genera have become naturalized. Three genera (*Artemisia*, *Bidens*, and *Gnaphalium*) have both native and naturalized species. Many of these are common weeds but some have proven to be highly invasive. In Hawaii, there are now four species of the genus *Senecio*, including *S. madagascariensis*; all are immigrants that have become naturalized.

S. madagascariensis is commonly known as fireweed, Madagascar fireweed, Madagascar ragwort, and common groundsel. It is a low (10 to 50 cm), upright, branched herb with variable growth habit and leaf structure. In coastal areas of Australia, it is usually observed as a low, heavily-branched, short-lived perennial bush. Generally, the leaves are bright green, alternate, and narrow with serrated, entire, or lobed margins. The broader leaves are 2 to 6 cm long, occasionally 8 to 10 cm on mature plants. The flowers are small (1 to 2 cm in diameter), yellow, and daisy-like, usually with 13 petals, and can number from 2 to 200 per plant. The seeds are small (1 to 3 mm in length), light, slender, and cylindrical in shape with a downy surface, and attached to a pappus of fine, silky, white, feathery hairs. The plant has a shallow, branched tap root with numerous fibrous roots, growing from 10 to 20 cm deep. (Allan, et al., 2001).

Life history of the target organism

Fireweed is highly adaptable to changes in the environment. In Australia, the plant behaves as a short-lived perennial under favorable conditions, but, under arid conditions, it behaves as an annual. In the field, various stages of development from seedlings to flowering plants can be observed throughout most of the year. Germination of the seeds depends on rainfall, but is also stimulated by light and warm temperatures. Flowers are produced 6 to 10 weeks after seedlings emerge. The seeds can germinate immediately after they are released from the flower head. Thus, the plant may produce 6 to 8 generations per year. The light, fluffy seeds are readily spread by wind, which is considered to be the major factor for dispersal over large areas and long distances. They can also be spread in hay and grain products, on clothing and vehicles, and by livestock, birds, and other animals. Fireweed plants can produce large quantities of seed over a

long period. Each flower produces between 100 and 150 seeds. Thus, a single large plant has the ability to produce approximately 25,000 or more seeds with high viability. Fireweed can also grow vegetatively. Stems root at the nodes when in contact with moist soil. Fireweed has the ability to grow on a wide range of soil types from fertile clay soils to sandy soils low in fertility, but the optimum soil is one that is well-drained and lighter in texture. (Allan, et al., 2001).

Pest status of the target organism

In Hawaii, fireweed has been declared a noxious weed under Chapter 68, Hawaii Administrative Rules (HAR) and a pest for control or eradication in Chapter 69A, HAR. Its seed is a prohibited noxious weed seed in Chapter 67, HAR.

Fireweed is an invasive plant that quickly infests heavily grazed or neglected pastures, cultivated land, and other disturbed sites. It is a strong competitor against pasture forage plants for light, moisture, and soil nutrients, particularly phosphorus and nitrogen (Allan, et al., 2001). Fireweed is an opportunistic weed with the ability to invade a wide range of habitats in a short period of time. In Australia, *S. madagascariensis* has had a significant impact on agriculture as a result of its invasiveness, competitiveness with pasture forage, and toxicity to livestock. In combination with its high seed production, ease of distribution, adaptability and variability in the field, germination, growth, and flowering during much of the year, alkaloid content, and the absence of effective natural enemies in its new range of distribution, fireweed readily achieves its invasive potential. Fireweed plants produce large numbers of viable wind-blown seeds which form dense infestations. The seedlings develop rapidly and produce flowers as early as six weeks after emergence. The avoidance of the weed by cattle greatly favors its growth and competitiveness, and reduces pasture yield and grazing area (Sindel, 1996).

Fireweed, like many other Senecio species, contains a pyrrolizidine alkaloid, believed to be senecionine (McBarron, 1976), which is toxic to livestock. When ingested, it accumulates in and damages the liver resulting in the reduction of growth of these animals and, in severe cases, death. The disease is progressive, with symptoms and mortality occurring weeks or months after consumption of the plants (Bull, 1955).

C. Biology of organism to be released

Secusio extensa (Butler) (Lepidoptera: Arctiidae) Life History

S. extensa eggs are dome-shaped, 0.8 mm in diameter, 0.75 mm in height, and smooth with no reticulations. They are creamy to white when freshly deposited and turn black one day before hatching. Usually, the eggs are laid singly or in batches of up to 62 eggs with unmated females more apt to lay eggs singly or in smaller batches of up to 35 eggs. The eggs of this moth, in the field, are usually laid on the underside of leaves. The upper side of leaves, stems, and, occasionally, flower heads may be used as oviposition substrates. In the laboratory, females lay eggs on the sides of plastic rearing containers and cage surfaces (glass, metal, and screen) and frequently deposit fresh eggs onto previously laid batches. Unlike other Lepidoptera, the presence of a host plant in a rearing container is not necessary for oviposition. Mean egg

duration is 5.7 days at ambient temperature. The egg hatching rate was estimated from random samples taken from every generation. Mean egg hatch for the first 21 generations (all reared on fireweed under quarantine conditions) from a total of 8,312 eggs was 77.3 ± 5.3% and ranged from 36.2% to 98.3%, depending on the mating rates among cohorts.

The larval stage consists of five instars. Young larvae (first two instars) feed gregariously on the lower surface of leaves and disperse as they mature. The head of the larva is smooth with only primary setae and six ocelli. The head is covered dorsally by long thoracic setae. Like on most arctiids, the body of the larva is densely covered with dark, plumose setae. The larvae crawl rapidly and feed at night. Feeding on fireweed, first instar larvae increase in size to a length of 2.8 mm with a head capsule width of 0.4 mm during a period of 4.3 days. The head capsules of first instar larvae are dark brown, yellow in the next three instars, and light brown in the fifth. When the host plant is not found, first instar larvae may feed on other eggs in the rearing container. However, larval cannibalism has never been observed among the five instars. If the natural host (fireweed) is not available, first instar larvae perish within 48 hours without any sign of feeding on each other. First instar larvae are capable of producing silken thread when brushed away from the host. Succeeding instar larvae do not and, thus, prefer to curl and drop from the plant when disturbed. Second instar larvae increase in size to 5.8 mm long with a 0.59 mm wide head capsule that is yellow during a period of 3.0 days. Third instar larvae grow to 9.9 mm long with a 0.83 mm wide head capsule during a period of 3.9 days. Fourth instar larvae enlarge to 13.9 mm long with a 1.4 mm wide head capsule during a period of 4.3 days. Fifth (final) instar larvae increase in size to 26.4 mm in length with a head capsule width of 2.2 mm during a period of 7.3 days. This duration is highly variable, depending on the quality of the host plant.

Larval feeding, as observed from the damage done to fireweed host plants, increases significantly with each instar during the larva stage spanning just over three weeks. Voracious feeding by fifth instar larvae is the most damaging to the plant as they devour the leaves and may even strip the outer layers (epidermis and cortex) of the stems. They apparently do not have a liking for the fireweed inflorescence because, most of the time, these are left intact. Fifty *S. extensa* larvae (fifth instar) are able to completely defoliate four full-grown fireweed plants in one-gallon plastic pots confined in a cage. These plants never recover from the defoliation and they all die. The fifth instar larva spins a light silken cocoon sprinkled with larval setae. Mature larvae usually pupate between layers of newspapers at the bottom of the rearing cage. Unlike other arctiids, no pupae are formed on the walls of the cages or on the plants. The prepupa loses most of the long setae, becomes about one cm shorter than the average mature larva, and remains as a prepupa for a day before developing into a pupa.

The pupa is obtect, about half the length of a mature larva, stout, and brown with dark stripes. The forewing has eight dark longitudinal bands. All abdominal segments have dark stripes. The antenna of the male has a dark stripe on the outer margin extending for more than half its length. It extends to less than half the antennal length in the female pupa. The pupa has seven pairs of spiracles on abdominal segments two to eight. The ninth abdominal segment of the male is complete, bearing a genital slit between two slightly elevated kidney-shaped pads. The eighth abdominal segment of the female is divided by the ninth with a genital opening in the middle. The male pupa is slightly smaller in length and width than the female pupa. The duration of the pupal stage is 11.3 days for both sexes. The whole life span of *S. extensa* is 41.1 days, producing

up to nine generations per year when the larvae are fed fireweed under conditions that exist in the HDOA Insect Containment Facility.

The adults are medium-sized, beige-colored moths with various shades of brown mottling on the forewings, including many small, dark brown spots on the proximal portion of the forewings and, also, on the pronotum. There are larger dark brown spots aligned on the mid-dorsum of the beige thorax and on the yellow-orange, somewhat elongate, yet truncated abdomen. The wings of the adults, when at rest, are held roof-like over their bodies. The adults are nocturnal.

Natural Geographic Range of *S. extensa*

Caterpillars of the fireweed moth, *S. extensa*, were collected from the southern region of Toleara Province, Island of Madagascar, in October 1999. Young and mature larvae were collected from fireweed infested plants at three localities along the sand dunes of the Indian Ocean. Collection sites were at Saint Luce, Evatra, and Fort Dauphin. Elevations of the three sites ranged from 6 to 79 meters and day temperature ranged from 24 to 34 degrees C. Larvae were reared to the pupal stage on field collected fireweed cuttings immersed in water. The initial cohort produced from this collection consisted of 606 pupae, which resulted in the emergence of 398 adults (34% pupal mortality) with a sex ratio of 51.7% females. A laboratory colony was established on potted plants or cuttings of fireweed for studies on bionomics and host range. *S. extensa* is considered to be the most damaging insect to fireweed during the summer season in Madagascar. Heavy feeding caused rapid destruction of the plants during this time of the year. An average of eight larvae was observed feeding on each plant in the native region.

Identification of *S. extensa* is credited to Dr. John Rawlins, Associate Curator at the Carnegie Museum of Natural History, Section of Invertebrate Zoology, Pittsburgh, PA. There is no published information on the life history of this moth. The genus contains a number of other species of which *Secusio pustularia* Walker and *S. pulverata* from mainland Africa are closely related (Mlawula Nature Reserve Fauna 2005). The larvae are very close to members of the subfamily *Nyctemerinae*, many of which are obligate feeders on species of the tribe *Senecioneae* (*Emilia*, *Senecio*, and other genera) (DaCosta and Weller 2005).

There are mixed taxonomic opinions on the genus identity of this moth. Butler first described *S. extensa* under the genus *Sommeria* from specimens collected in Madagascar at Betsileo. It was later placed in the genus *Diota* and subsequently changed to *Galtara*. The type species is *Galtara extensa* Butler, the only species in this genus from Madagascar. *Galtara purata* Walker, 1860, is the type for genus *Galtara*, and *Secusio strigata* Walker, 1854, is the type for genus *Secus*io. If *G. purata* and *S. strigata* are congener, then the senior valid generic name would be *Secusio*. Until this problem is solved, Systematist J. Rawlins prefers to place it under the senior name *Secusio* (J. Rawlins, personal communication). Nonetheless, ever since this species was described by Butler in 1880, there have been no records for both names (*G. extensa* or *S. extensa*) anywhere in the world to indicate that this insect is a pest on any crop or that it has a preference for any plant other than herbs and weed members of the tribe *Senecioneae*.

The other mottled beige arctiid species in mainland Africa is *Diota rostrata* and this too has been found only on *Senecioneae*. USDA is now considering it for use in California for biocontrol of

Delairea odorata, formerly *Senecio mikanioides* (Wing 2005). *Secusio pustularia* Walker is another related species commonly found in Mlawula, Swaziland. There are no records to indicate that it is a pest of any African crop or other plants of value.

While other species of the genus *Secusio* (*S. pulverata*, *S. pustularia* Walker, *S. strigata*, *Secusio spp*.) are common on the African continent (Swaziland, Rwanda, and South Africa), *S. extensa* is not recorded in any survey. It is only found in Madagascar in habitats where populations of *S. madagascariensis* are present. Two field surveys were conducted by Ramadan in Madagascar during the summer (October 1999) and the rainy seasons (April 2005). During these seasons, examination of all plants around and in between fireweed populations infested with *S. extensa* indicated that this insect was found only on *S. madagascariensis*. Plants examined included those in the families Asteraceae and Rubiaceae, and also sweet potato, cassava, cucurbits, rice, pineapple, tomato, and various grasses. Close examination of four common herbs of Asteraceae (*Emilia tranvaalensis, Tridax procumbens, Sonchus oleraceus*, and *Bidens pilosa*) present at the survey sites in Madagascar showed that the plants were not attacked by *S. extensa* larvae.

Host range of *S. extensa*

Appendix 1 (pp. 24-27) lists the known host range of *S. extensa*, as determined by exposures of test plants to adults for oviposition and to larvae for feeding tests during host specificity studies in cages in quarantine. Studies included both no-choice and choice host testing.

Host Range List

No information on non-target hosts of this moth could be found in the literature. The only information found in literature on *Secusio extensa* was taxonomic. There was no available information on the biology and habits of this moth species.

Parasites/hyperparasites

Parasitoids of *S. extensa* were not found during field explorations in East Africa, during the unpacking and processing of the collected materials, and during propagation and colonization of the species in the HDOA Insect Containment Facility in Honolulu.

Status as hyperparasite

Not applicable.

III. Alternatives to the Proposed Action

The actions being considered in this DEA are (1) No Action (not issuing a permit) or (2) issuing a permit for release of *S. extensa*. The no action alternative is equivalent to an acceptance of the types and intensities of current impacts associated with infestations of fireweed. The issuance of a permit would result in releases of *S. extensa* that would, if successful, remove the undesirable

influence of fireweed on the environment, and those of alternative control practices on fireweed in the absence of *S. extensa*.

IV. Environmental Impacts of the Proposed Action and Alternatives

Expected environmental impacts of the proposed release

Field observations in Madagascar of *Secusio extensa* and quarantine studies in Hawaii strongly indicate that the proposed release of this fireweed biocontrol agent will not have any undesirable, negative, non-target effects on the natural environment of the Hawaiian Islands. Environmental impacts associated with the no action alternative of not issuing permits for release of *S. extensa* are those resulting from damage to the environment and the cattle industry caused by fireweed infestations and those caused by other methods employed to control fireweed infestations (both types of impacts are now occurring). The proposed release and establishment of *S. extensa* is intended to reduce these impacts. In the absence of effective natural enemies of fireweed, possible negative environmental impacts caused by repeated use of herbicides to control fireweed infestations add to the existing negative impacts caused by the displacement of desirable plants by fireweed. Use of chemical herbicides to control fireweed would be reduced if the proposed biological control agent becomes permanently established in the environment and is able to sufficiently impact population densities of fireweed. The suppression of fireweed to very low densities will greatly reduce the incidence of fireweed poisoning of cattle. The probability of establishment and degree of control can only be determined after the proposed releases are made.

Potential impacts on human environment

There will be no impact of the release of this moth on the human environment in Hawaii. No negative impacts on human activities are anticipated. A positive impact would be the reduction of fireweed in pastures and rangelands, thus reducing the opportunities for cattle and other grazing animals to be poisoned from the ingestion of fireweed plants or plant parts and, thereby, greatly reduce opportunities for the poison to taint beef for human consumption. No desirable animal is known to intentionally feed on any part of the fireweed plant, so the suppression of fireweed will not deplete the food source of any animal.

Literature search for other host records

As reported previously in this document, literature search for information on *Secusio extensa* disclosed that no information was available other than those regarding the taxonomy of this species. Also, there was nothing to indicate that *S. extensa* had ever been used for biological control anywhere else in the world. Thus, the only information presently available on host records is found in the research paper by Ramadan (Appendix 1) of his studies of the bionomics and host range of *S. extensa*.

Host specificity in country of origin

Field observations by Ramadan during his explorations for natural enemies of fireweed in Madagascar left no doubt that *Secusio extensa* larvae would restrict its feeding to *Senecio madagascariensis* (fireweed). *S. extensa* larvae were never found feeding on any other plants, including those in the family Asteraceae and, even more specifically, there was no evidence of feeding on *Emilia* spp., which is in the same tribe Senicioneae as fireweed, even though the larvae were readily observed on fireweed plants growing in close proximity.

Interactions with established biocontrol agents

S. extensa may interact with other natural enemies introduced to control fireweed in the future. However, no adverse impact on the other agents is anticipated from the presence of this new biocontrol agent in Hawaii. This moth will put a great deal of stress on fireweed plants by defoliating them. Since no insect has ever been purposely introduced to attack fireweed and no insect already present in Hawaii has ever been observed feeding on fireweed foliage, no interaction with other insects will likely occur.

Field observations in Madagascar and host specificity tests in quarantine in Hawaii have confirmed that *S. extensa* will not attack non-target plant species and, thus, will not have any negative impact on the natural environment in Hawaii.

Potential impact on T&E species

As a result of field observations in Madagascar and host specificity studies in quarantine in Hawaii, no negative impact on any endangered or threatened species of plant or animal is anticipated.

Impact to related non-target potential hosts

Field observations in Madagascar and host specificity studies in quarantine in Hawaii have clearly shown that *S. extensa* will have no negative impact on non-target potential hosts in Hawaii, including plants in the same family (Asteraceae) and even those in the same tribe (*Senecioneae*).

Potential of *S. extensa* to act as a hyperparasite

Not applicable. There is no data that would suggest that *S. extensa* could possibly act as a hyperparasite. Although a predatory caterpillar has been discovered in Hawaii, there are no hyperparasitic Lepidoptera anywhere in the world. With the exception of the predatory caterpillars, all Lepidoptera are phytophagous insects.

Potential of *S. extensa* to attack non-targets

During host specificity testing, the only plant species on which *S. extensa* larvae fed significantly in no-choice tests and matured to pupation were fireweed, *Senecio madagascariensis*, and three

other naturalized weeds. If and when *S. extensa* is released into the field, oviposition by the adults and feeding by the larvae is expected to be limited to the target species (fireweed, *Senecio madagascariensis*). Although the other three weeds (*Delairea odorata*, *Senecio vulgaris*, and *Crassocephalum crepidioides*), all of which are naturalized weeds in the same tribe as *S. madagascariensis*, appeared to be suitable hosts for *S. extensa* caterpillars during no-choice starvation testing, they were not given choice tests because none of them are native or of economic value and they all belong to the same tribe as the target pest. *Delairea odorata* Lemaire, which was formerly identified as *Senecio mikanioides* Otto and is commonly known as Cape ivy or German ivy, has recently become one of the most pervasive and alarming weeds in coastal areas of the western United States. This vine has also been declared to be an undesirable plant on the HDOA lists of noxious weeds, prohibited weed seeds, and plant pests (N. Matayoshi and B. Azama, HDOA, personal communication).

There were only three other test plant species (*Helianthus annuus*, *Emilia fosbergii*, and *Erechtites hieracifolia*) of a total of 71 species of endemic and naturalized plants tested on which the *S. extensa* larvae were able to feed and develop, but the incidence was very low and these plants are considered to be inferior hosts. Because the first species (*H. annuus*) is sunflower, additional testing was done even though damage was just incidental. Sunflower, which is in the tribe *Heliantheae*, was completely rejected by *S. extensa* in choice tests for larval feeding and adult oviposition. The other two species are common naturalized weeds. Fireweed and all five of the other weeds on which varying degrees of larval feeding and development occurred belong to the same tribe (*Senecioneae*). There are no endemic members of this tribe in Hawaii.

The attached report on the bionomics and host range studies of *S. extensa* in the HDOA ICF confirms that this fireweed biocontrol candidate is highly specific to *S. madagascariensis* and will not cause any unintended non-target impacts on the environment of the Hawaiian Islands.

V. Listing of Agencies and Persons Consulted

John E. Rawlins, Section of Invertebrate Zoology, Carnegie Museum of Natural History, Pittsburgh, Pennsylvania, on February 16, 2000, made the species determination of specimens of *Secusio extensa* (Butler) received from the Hawaii Department of Agriculture. According to Rawlins, he is not aware of anything that has been published on the life history of *S. extensa*. Having received specimens of larvae as well as adults, Rawlins stated that the larvae are very close to those of other nyctemerines, many of which are known to be obligate feeders on Senecioneae (*Emilia*, *Senecio*, and other closely related genera).

VI. References

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VII. Appendices

Appendix 1 - Ramadan, M. M. 2006. Bionomics and Host Range of *Secusio extensa* (Butler) (Lepidoptera: Arctiidae), a Potential Biocontrol Agent of *Senecio madagascariensis* Poiret (Asteraceae). Report of the Hawaii Department of Agriculture, Plant Pest Control Branch.

Appendix 2 – E-mail to Bernarr Kumashiro, dated February 16, 2000, from John E. Rawlins, Section of Invertebrate Zoology, Carnegie Museum of Natural History, Pittsburgh, Pennsylvania, regarding species determination of specimens of *Secusio extensa* (Butler) received from the Hawaii Department of Agriculture.