



**APHIS Evaluation of the Status of Panama
Regarding Screwworm (*Cochliomyia
hominivorax*)**

**Animal and Plant Health Inspection Service
Veterinary Services
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Abbreviations

APHIS	Animal and Plant Health Inspection Service
ARS	Agricultural Research Service
BPP	<i>Barrera Permanente de Prevención</i> (Permanent Preventive Barrier or Control Zone)
CFR	Code of Federal Regulations
CMA	<i>Control de Movilización de Animales</i> (Control of Animal Movement)
COPEG	<i>Comisión para la Erradicación y Prevención del Gusano Barrenador del Ganado</i> (Commission for the Eradication and Prevention of Screwworm)
COPFA	<i>Comisión Panamá-Estados Unidos Prevención Fiebre Aftosa</i> (Panama-US Comisión for the Prevention of Foot and Mouth Disease)
DECA	<i>Dirección Ejecutiva de Cuarentena Agropecuaria</i> (Executive Directorate for Agricultural Quarantine)
DINASA	<i>Dirección Nacional de Salud Animal</i> (National Directorate of Animal Health)
FAO	Food and Agriculture Organization of the United Nations
FMD	foot and mouth disease virus
FVE	<i>Franja de Vigilancia Epidemiológica</i> (literally strip or area of epidemiologic vigilance)
GBG	<i>gusano barrenador del ganado</i> (New World Screwworm; <i>Cochliomyia hominivorax</i>)
ICA	<i>Instituto Colombiano Agropecuario</i> (Colombian Agricultural Institute)
ISO	International Organization for Standardization
LADIVES	<i>Laboratorio de Diagnóstico de Enfermedades Vesiculares</i> (Laboratory for the Diagnosis of Vesicular Disease)
MIDA	<i>Ministerio de Desarrollo Agropecuario</i> (Ministry of Agriculture and Livestock Development)
OIE	Office International des Epizooties (World Organization for Animal Health)
OIRSA	<i>Organismo Internacional Regional de Sanidad Agropecuaria</i> (Regional International Organization for Plant Protection and Animal Health)
PANAFTOSA	Pan-American Center of Aftosa Fever Pan American Foot-and-Mouth Disease Center
SW	screwworm (<i>Cochliomyia hominivorax</i>)
UNESCO	United Nations Educational, Scientific and Cultural Organization
USD	United States Dollar
USDA	United States Department of Agriculture

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Executive Summary

Panama submitted a request to the United States Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) seeking recognition as a region free of the *Cochliomyia hominivorax* screwworm (SW). To accomplish this, a country needs to be removed from the list of affected countries in Title 9, Code of Federal Regulations (9 CFR 93). This requires rulemaking. Upon receipt of the request, APHIS initiated an evaluation of the status of the Republic of Panama with regard to SW to assess the risk of exempting Panama from current CFR restrictions by removing Panama from the list of SW affected countries.

The eradication and prevention of SW in Panama was the result of a cooperative program strongly supported by USDA using the systematic release of adult *Cochliomyia hominivorax* flies sterilized by exposure to irradiation. The sterile fly mates with the native fertile female fly population to produce sterile eggs, interrupting the lifecycle resulting in eradication of the population [14]. This effort resembles the SW eradication and prevention cooperative programs utilized in Mexico and the other Central American countries which APHIS currently recognizes as SW-free. All of these programs used the sterile fly dispersion methodology and all have remained successfully SW free since eradication was completed.

In 1998, Panama began field activities as a cooperative program involving Panama's Ministry of Agriculture and Livestock Development (*Ministerio de Desarrollo Agropecuario, Dirección Nacional de Salud Animal* (MIDA)), Commission for the Eradication and Prevention of Screwworm (*Comisión para la Erradicación y Prevención del Gusano Barrenador del Ganado* (COPEG)) and the United States Department of Agriculture (USDA). The permanent biological barrier was established in the Darien Gap region adjoining Colombia and the continent of South America in 2001.

The success of the sterile fly release method has resulted in the eradication of SW from all of Central America and the establishment a permanent biological barrier between Central American and the South American continent maintained through the continued release of sterile flies, intensive monitoring and movement controls. This permanent biological barrier was established in the sparsely inhabited Darien Gap area of Panama, an area roughly 100 miles long and 30 miles wide. The area has a very low human and domestic animal population and has no major roads connecting the Republic of Panama into Colombia.

The US is evaluating the SW status of Panama because of the potential risk of introduction of SW from Panama to the US. Therefore, the assessment evaluated the infrastructure, and control measures in place for SW and includes an assessment of SW surveillance measures, laboratory capacity, emergency response procedures, and other factors that could influence the risk of SW introduction into the United States. Supporting documentation for this risk analysis consists of documentation provided by MIDA, COPEG, USDA and other technical sources that could influence the likelihood of disease introduction into the United States.

This risk analysis was conducted according to OIE guidelines and therefore includes hazard identification, release assessment, exposure assessment, consequence assessment, and risk estimate [12]. The documentation provided indicates that SW has been eradicated in Panama.

Hazard identification

The hazard under consideration is New World Screwworm (*Cochliomyia hominivorax*) (SW).

Release assessment

APHIS finds that SW was successfully eradicated from the Republic of Panama outside the area of the Darien Gap and that an effective prevention program is in place based on the establishment and maintenance of a permanent biological barrier in the Darien Gap. Eradication was accomplished through the release of sterile male flies. Although SW was eradicated in the Darién Gap, assurance that SW is not reintroduced into Panama is supported by the continued monitoring and release of sterile flies, even after eradication.

APHIS has no evidence that SW currently exists in Panama as SW has not been detected in domestic livestock outside the permanent biological barrier since 2003. Panama's current surveillance practices for SW are such that an incursion of SW would be recognized and the veterinary infrastructure is well trained and equipped to contain and eliminate an outbreak. The biological barrier ensures that SW will not be released into Panama from the South American continent. The maintenance and monitoring of the permanent biological barrier in the Darien Gap is the responsibility of COPEG, supported by the cooperative efforts of USDA and MIDA. If SW were reintroduced into Panama, it would likely be detected and contained before spreading.

The likelihood of introduction of SW into the US is limited to the importation of SW infested live animals, as *Cochliomyia hominivorax* larvae survive only in living tissues. Therefore, there is no risk associated with the importation of commodities such as meat or animal byproducts. To pose a risk for US livestock, an infested live animal would have to be imported, the infestation remain undetected and untreated, followed by the emergence of viable larvae from the wound and successful pupation in soil resulting in the emergence of fertile flies. These fertile flies would need to mate successfully and depositing fertile eggs in the wound of a domestic animal. The management and inspection practices in the US associated with the care of animals of sufficient value to warrant importation would be likely to result in the treatment of infested wounds resulting in the elimination of viable larvae. General good animal husbandry practices, which include insect control measures, would further mitigate the likelihood of introduction and establishment of endemic SW in the US.

Panama shares a common land border with Colombia, a region that APHIS does not consider to be free of SW. In this regard, the risk profile of Panama resembles that of countries where SW was previously eradicated, such as Mexico and the Central American countries when the successful cooperative eradication programs were completed but the country shared a border with a country that remained affected with screwworm.

Exposure Assessment

APHIS assessed the probability of exposure of susceptible animal populations in the United States to SW carried by imported livestock from Panama. APHIS considers that the most likely pathway of exposure of US cattle and other species susceptible to SW is through contact with infected/infested animals under conditions that would allow completion of the SW lifecycle [11]. Other more indirect exposure pathways, such as through animal products, are not likely to result in infection/infestation because the larvae of the SW do not remain viable in other media except viable flesh.

Consequence Assessment

APHIS also assessed the biological and economic consequences of introducing SW into the United States. This assessment concluded that SW has the potential to cause significant distress and suffering in affected animals. The economic costs of control and eradication would be substantial if *Cochliomyia hominivorax* were to become established in the United States. The magnitude of the biological and economic consequences following an introduction of SW would depend on the location, time of the year, the rate of spread, ability to detect the disease rapidly, demographics and movement patterns of susceptible species, and relative ease of employing eradication procedures. Direct consequences include effects of the disease on animal health, subsequent production losses, total cost of control and eradication, the effect on the environment, and public health consequences. Indirect consequences, including impacts on international trade and associated domestic consequences, are not likely to result from an outbreak of screwworm because of the existing available treatment options.

Risk estimate

In summary, although a SW outbreak in the United States would be likely to have animal health and economic consequences, APHIS considers the risk of infected live animals entering the United States from the Republic of Panama and exposing U.S. livestock to be low.

Introduction

Panama submitted a request to the Animal and Plant Health Inspection Service (APHIS) seeking recognition as free of *Cochliomyia hominivorax*, known more commonly as New World Screwworm (SW) [10]. This risk analysis was conducted according to the format recommended by OIE and, therefore, includes hazard identification, release assessment, exposure assessment, consequence assessment, and risk estimate [12].

Hazard identification

The hazard under consideration is SW.

History of SW in the US

The US reported the presence of SW as early as 1825 in the Western States. By 1933, SW had migrated from the Southwest to the Southeast United States in a shipment of infested animals and within the year six states in the southeast were infested [7]. The economic impact in the southeastern States at this time was substantial with producers experiencing losses of \$400 million annually. In 1935, in spite of control efforts approximately half the counties in Texas were infested, resulting in 180,000 livestock deaths [5].

Eradication of SW was not practical until the development of the sterile fly release technique. SW was first eradicated using sterile fly release in Florida in 1959, however, quarantine regulations were difficult to enforce and small reinfestations continued to be reported in Florida, southern Alabama, and Louisiana. These reinfestations were successfully controlled by saturating the areas of the outbreak with sterile flies.

Eradication of indigenous SW in the US was completed by 1966. However, sporadic outbreaks continued to appear as the result of SW flies entering from Mexico. In 1972, the United States experienced its worst outbreak of SW cases since 1966 when California, Arizona, New Mexico, Texas, Oklahoma, and Arkansas reported SW-infested livestock. In 1972 Texas confirmed 90,000 cases, after reporting 444 in 1971. The resources to contain this outbreak were considerable. Plans were then developed to progressively eradicate SW in Mexico and establish a biological barrier to prevent incursion of the SW fly into the US. The eradication of SW in Mexico began in 1972 at the Texas-Mexico border and progressed southward until eradication was completed in 1991 [14].

Following eradication of SW in the US, several limited outbreaks have occurred in the US as the result of importation of infested live animals. In 1997, SW larvae were detected on a dog shipped to San Antonio, TX, from a US military base in Panama [5]. In 1998, following the positive identification of SW larvae in a goat in Texas, more than 40,000 head of livestock and dogs in the area were examined for signs of SW infestation. Fortunately, no other larvae were found before the onset of cold weather eliminated the

potential for any SW flies present to winter over; however, the origin of the SW was never confirmed.

In 1999, SW larvae were found in a horse imported from Venezuela. In 2000, one of 16 horses shipped to Florida from Argentina was discovered to have SW larvae in a wound, however, none of the other horses showed any signs of SW. In this case the SW larvae were at least 24 hours from maturity and it was considered unlikely that any larvae had dropped from the wound. As a precaution, the premises were treated to ensure that any larvae that might have exited the wound were destroyed [4]. These findings prompted APHIS to respond with an emergency action and put in place an interim rule to institute inspection and treatment for SW for horses, ruminants, swine, and dogs for animals imported from countries considered to be affected by SW [2]. The interim rule was made final in 2002 [4]. Panama was included in the list of SW affected countries in Title 9, Code of Federal Regulations (9 CFR) when the SW regulations were put in place in 2000¹.

History of the Screwworm Eradication Program

The Screwworm Eradication Program in Panama was established in 1994 through the cooperative efforts of the government of Panama and the Animal and Plant Health Inspection Service of the United States Department of Agriculture (USDA-APHIS). The Screwworm Eradication Program utilizes the Sterile Insect Technique to release sufficient numbers of sterile male SW flies to mate with the wild fly population.

Following successful eradication of SW in the United States, the Sterile Fly Release Program was expanded into Mexico in 1972 to establish a biological barrier at the Isthmus of Tehuantepec in southern Mexico. Eradication in Mexico was completed in 1991. The Program was later expanded with the goal of covering the entire Central American Isthmus and Panama and eventually reaching the Darien Gap area on the border with Colombia. The Screwworm Eradication Program progressed southward toward Panama, completing eradication in Belize and Guatemala in 1994, El Salvador in 1995, Honduras in 1996, Nicaragua in 1999 and Costa Rica in 2000.

Use of the Sterile Insect Release Technique to eradicate *Cochliomyia hominivorax* has proven to be a very efficient eradication technique because the female fly mates only once while the male mates many times so that sterile males can mate multiple times with the fertile wild females. The result of mating with a sterile male is the production of non-viable egg masses which interrupt the insect's life cycle. In this way the release of sufficient numbers of sterile males in an area results in eradication after several lifecycles. In Panama, the flies will continue to be released in the permanently established biological buffer area at the Darien Gap to prevent reintroduction across the Colombia border from the South American continent where SW remains endemic.

¹ Title 9, Code of Federal Regulations (9 CFR); SW affected countries are listed specifically in 93.301(j) horses; 93.405(a)(3) ruminants; 93.505 swine(b) and 93.600(a) dogs. 9 CFR 71.3(b) lists SW as a disease not known to exist in the United States.

Sterile SW flies are artificially raised in a laboratory and sterilized by exposing them to a low dose of irradiation just before they pupate. Irradiation at this time inhibits the development of the ovaries in females and the testes in males without affecting any other body part resulting in normally developed but sterile adult flies. The sterile flies are dispersed by airplane on regular intervals at controlled density to saturate an area.

The original sterile fly production plant for the program was in Mission, Texas and was replaced by a plant at Tuxtula, Gutierrez, Chiapas Mexico in 1976. Construction on the Panama Mass Rearing and Research Facility began in February, 2004, in Pacora, Panama, about 25 miles east of Panama City where sterile fly production will begin in 2008 [2, 3, 4, 7].

Hazard Identification

APHIS identifies several animal diseases listed by OIE as hazards when considering trade in animals and animal products from foreign regions [13]. One of these diseases is SW. SW is exotic to the United States; therefore, before opening trade in live animals with a region or country considered to have been affected with SW, APHIS conducts an import risk analysis. OIE does not suggest restrictions on the import of animal products because the SW larva cannot survive for any length of time in dead tissues or animal products [13].

The New World screwworm, *Cochliomyia hominivorax*, is an obligate parasite of warm blooded animals during its larval stages. *Cochliomyia hominivorax* is in the subfamily Chrysomyinae of the family Calliphoridae (dipterous flies) of the order Diptera (true flies) that is endemic only in the tropical and subtropical regions of North, Central, and South America. In the Spanish language, SW is known as the gusano barrenador del Ganado (GBG) and may also be referred to as Coquerel.

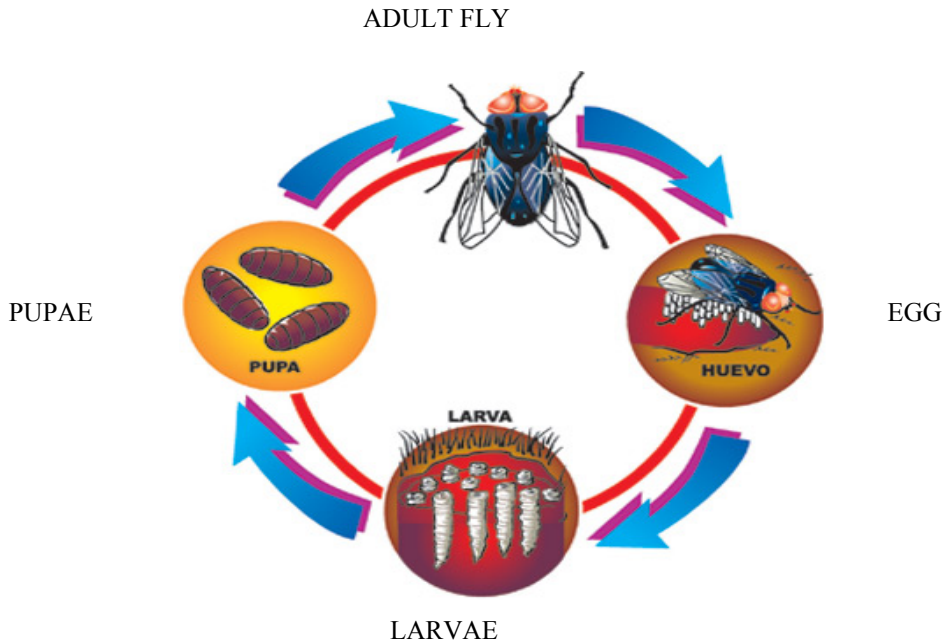
Cochliomyia hominivorax is a serious pest of warm-blooded animals, capable of causing injuries and death to livestock, domestic animals, occasionally birds and infrequently human beings. *Cochliomyia hominivorax* infestation occurs when the eggs hatch in the wound and the larvae feed on the animal's flesh. Unlike most other species of blowflies, adult female SWs do not lay their eggs on carrion [13]. The female SW fly lays her eggs only in the flesh of living animals, at the edges of wounds or body orifices. Individual females lay eggs in clusters of 300 eggs tightly adhered to each other and the wound substrate. Virtually any wound is attractive, whether natural (from fighting, injury, predators, thorns, disease, and/or tick and insect bites) or man made (from shearing, branding, surgical sites, castrating, de-horning, docking, and/or ear-tagging). Commonly infested natural wounds are the navels of newborn animals and the vulval and perineal regions of perinatal animals, especially if traumatized. If eggs are deposited on mucous membranes, the larvae can invade natural body openings such as the nostrils and associated sinuses, the eye orbits, mouth, ears, and genitalia.

Multiple infestations are typical with additional female SW flies depositing their eggs. As many as 3,000 larvae may be found in a single wound. A bloody discharge often exudes from the infested wounds, frequently accompanied by a distinct fetid odor. Infested animals usually exhibit discomfort, may go off feed, and may separate themselves from the rest of the flock or herd to seek shady or secluded areas to lie down. Animals with severe SW infestations may die in 7 to 14 days if wounds are not treated to kill the larvae, especially in cases of massive infestations. Death is generally the result of toxicity and/or secondary infection. However, most cases are less severe and characterized by weight loss and secondary bacterial infections [11].

The larvae typically emerge from the egg within 12-24 hours but may emerge as early as 8 hours after being deposited in the wound [7, 11]. The freshly emerged larvae immediately begin to feed by burrowing into the wound to feed on the underlying tissues, enlarging and deepening the wound [11]. Enlargement of the wound attracts additional

SWs. Larvae feeding on the skin and underlying tissues of the host cause a condition known as wound or traumatic myiasis. Within the wound the larvae undergo two moults before reaching maturity at 5-7 days after hatching. The larvae then leave the wound, fall to the ground to burrow and pupate between one week and several months [11].

Figure 1. Simplified screwworm (*Cochliomyia hominivorax*) life cycle [6]



The duration of the life-cycle is temperature dependent and under tropical or semitropical conditions the whole cycle may be completed in less than 3 weeks [6]. The most profound effect of ambient temperature is on the off-host pupal stage, which can vary from 1 week to 2 months' duration depending on the season. In cooler weather the complete life cycle may take up to 2-3 months, however with an average air temperature of 22°C (71° F) it is completed in about 24 days, and in tropical conditions averaging 29°C (84° F) it may be completed in only 18 days. SW cannot winter over well under non-tropical conditions, preferring hot humid conditions and may only sustain an endemic population in tropical to semi-tropical areas [9, 11, 14].

Male *Cochliomyia hominivorax* flies become sexually mature and able to mate within 24 hours of emerging from the pupa. Female *Cochliomyia hominivorax* flies are responsive towards males and mate approximately 3 days after emerging from the pupa. Male *Cochliomyia hominivorax* are aggressive breeders and mate frequently but females mate only once; thus the mating of sterile male flies with the fertile (wild) females resulting in production of sterile eggs serves to break the life cycle. About 4 days after mating, female flies are ready to lay their fertilized eggs (oviposit) in batches of up to 300 eggs and are able to lay up to 4 egg batches at 3 to 4 day intervals. Adult flies live on average for 2-3 weeks under field conditions but may live up to 60 days under optimal conditions [9, 11, 14]. They are powerful fliers with a potential range of 20 to 30 miles, although

they may range over considerably longer distances if carried by the wind or in search of an appropriate host in which to lay their eggs in areas of sparse animal density.

Cochliomyia hominivorax diagnosis is readily done by microscopic examination of the larvae, pupae or adult stages. Physical distinctions at all stages can be used to differentiate *Cochliomyia hominivorax* from some 20 species of flies capable of producing myiasis. This includes, among others, members of the Calliphoridae family, such as the closely related *Cochliomyia macellaria* (common name- Fabricius or secondary screwworm) or *Phaenicia* spp. (common name- bottle flies). Another dipterous fly with neotropic distribution in the Cuterebridae Family, *Dermatobia hominis* (common names- human bot fly, American Warble or Torsalo), is also frequently associated with myiasis and has a multiple host range.

Cochliomyia hominivorax infestation may be treated with topical or systemic application of approved chemicals to kill the larvae (9 CFR 93). The larvae should be physically removed from the wounds with tweezers and wounds should be treated until the wound is completely healed. Treating wounds and spraying or dipping animals with an approved product such as organophosphates or other insecticide will provide protection against SW for up to 7 to 10 days. However, the most effective way to control SW infestation remains eradication.

Release Assessment

A release assessment describes the biological pathway(s) necessary for an importation activity to introduce pathogenic agents into a particular environment and estimates the probability of that introduction [12]. This release assessment addresses the 11 factors described under 9 CFR 92.2 for evaluation of foreign animal disease status. Risk factors and issues of concern, which may directly or indirectly affect the risk estimate, are identified during this process. APHIS evaluated the current status of Panama with regard to SW to decide whether it can recognize Panama as SW free and remove it from the SW-affected list. This action would be taken based on the risk finding that susceptible animals originating in Panama would pose a very low import risk to the US.

Authority, organization, and infrastructure of the veterinary services

Screwworm eradication in the Republic of Panama was accomplished through a Cooperative Agreement, signed on February 11, 1994, between the Panamanian Ministry of Agriculture and Livestock Development (MIDA) and United States Department of Agriculture (USDA) [1]. The Cooperative Agreement establishing the Panama-US Commission to Eradicate and Prevent SW (*Comisión para la Erradicación y Prevención del Gusano Barrenador del Ganad*, COPEG) was created as a part of the USDA Regional Plan to eradicate SW in Central America. COPEG serves as the Veterinary Authority, and in this role directly controls the specifics of the eradication and prevention program with the full cooperation of Panama's veterinary infrastructure with financial and scientific support from USDA. COPEG applied the preexisting infrastructure and legal framework developed within Panama for the eradication of foot and mouth disease (FMD) and shares many of the resources developed under the *Comisión Panamá-Estados Unidos Prevención Fiebre Aftosa* (COPFA).

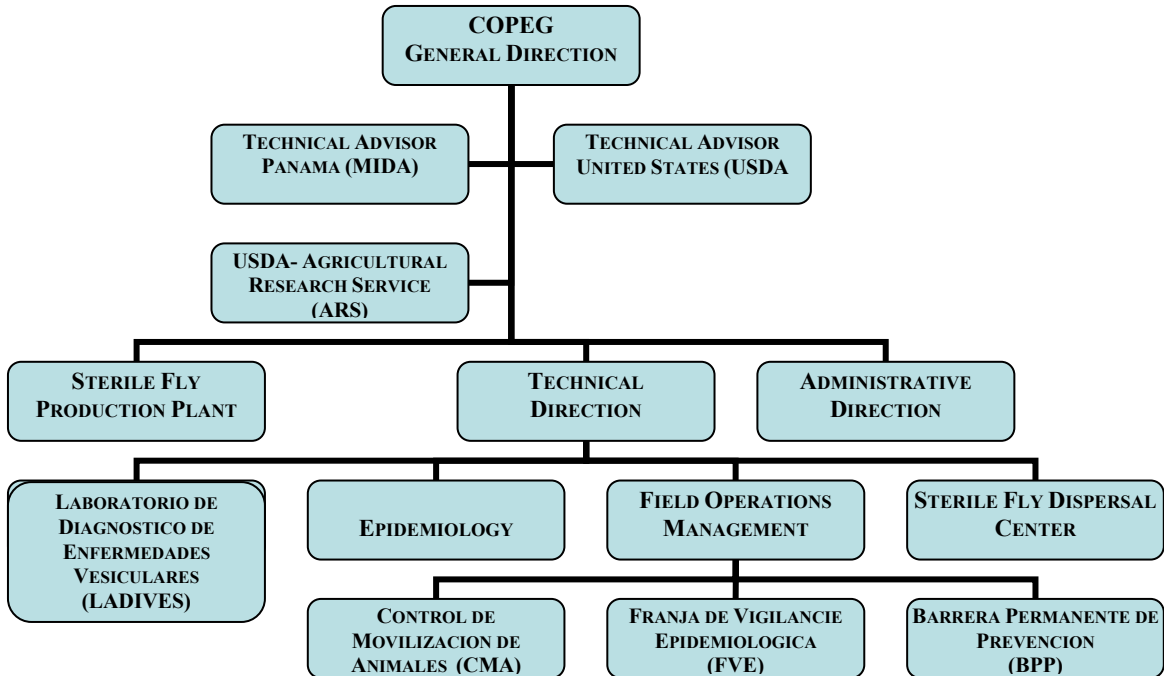
COPEG

As specified in the Cooperative Agreement, COPEG (also referred to as the Commission), has 2 full time Directors, one of which is a USDA official and other is the Panamanian MIDA Director. In addition, there are also 8 Commission members, 4 designated by the Secretary of the USDA and 4 designated by Panama MIDA. The Commission annually reviews all its activities, provides guidance and approves annual work plans and budgets. The Cooperative Agreement supports all phases of eradication and prevention.

The Cooperative Agreement provides COPEG with the legal basis to conduct the eradication and preventive phases of the SW program by mandating the development and execution of annual work plans. It provides for the necessary technical support activities including; establishment of animal quarantine control measures and treatment stations, maintenance of livestock census, SW surveillance, establishment and maintenance of laboratory support and aerial dispersion of sterile SW flies in Panama. The Cooperative Agreement provides for the training of personnel, development of general education efforts and conduct of periodic training exercises to support emergency outbreak response. The development of a contingency plan to respond to outbreaks is also part of the Cooperative Agreement [1].

Funding is provided jointly by USDA and MIDA. The Cooperative Agreement specifies that during the eradication phase, USDA provided 85% of the financial resources and MIDA provided the remaining 15%. Following completion of the eradication phase, the continued funding to maintain the permanent biological barrier is to be funded 90% by USDA and 10% by MIDA. Annually the cooperative eradication and prevention program has cost between \$7.8 and 10.5 million USD [8].

Figure 2. COPEG organizational chart.



Three groups within COPEG carry out the majority of field operations; *Control De Movilización de Animales* (CMA), *Franja de Vigilancia Epidemiológica* (FVE) and *Barrera Permanente de Prevención* (BPP). *Control De Movilización de Animales* (Control of Animal Movement or CMA) works with the Panamanian Ministry of Agriculture and Livestock Developments *Dirección Ejecutiva de Cuarentena Agropecuaria* (Executive Directorate for Agricultural Quarantine or DECA) to conduct field surveillance for SW and vesicular diseases at movement control points throughout the Republic of Panama. Field operations for disease control and surveillance measures are managed by *Franja de Vigilancia Epidemiológica* (FVE, literally strip of epidemiologic vigilance) and *Barrera Permanente de Prevención* (BPP, Permanent Preventive Barrier) maintains and monitors the permanent biological barrier in the Darien Gap.

Diagnostic support is provided by LADIVES (*Laboratorio de Diagnóstico de Enfermedades Vesiculares*). This lab was initially established to handle the diagnostic work for the FMD eradication and prevention efforts under the *Comisión Panamá-*

Estados Unidos Prevención Fiebre Aftosa (COPFA, Commission of the Panama-United States to Prevent Foot and Mouth Disease) and continues to do diagnostic work for FMD and other vesicular diseases. LADIVES also serves as the regional FAO Reference Laboratory.

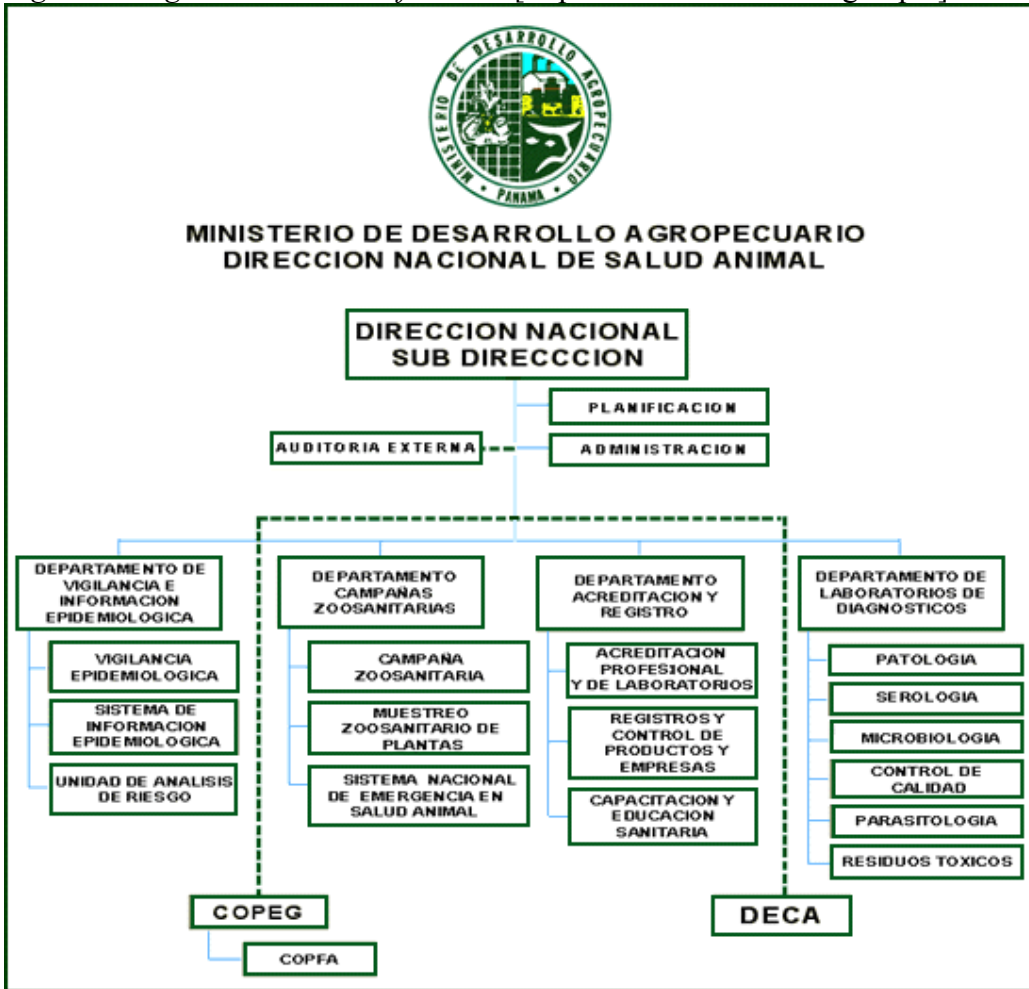
COPEG maintains approximately 90 full time inspectors with 53 working in the Darien Gap area of Panama along the Panama-Colombia border with an additional 40 inspectors in the free zone north and west of the Darien Gap to monitor livestock for both SW and FMD [6].

Republic of Panama

In the Republic of Panama, the Ministry of Agriculture and Livestock Development (*Ministerio de Desarrollo Agropecuario* or MIDA) is the federal department within the government of Panama responsible for the agriculture and livestock sectors. The roles and responsibilities of MIDA are considered equivalent to United States Department of Agriculture (USDA). MIDA has 10 Regional Directorates, one located in each province and two in the Province of Panama (East Panama and West Panama). MIDA, among other responsibilities, develops and maintains the legislation and enforcement capability to support the Cooperative Agreement including establishment of the authority to support quarantine measures, provides the authority to enter premises for Program purposes and establishment of mandatory reporting of suspected cases of SW. MIDA is responsible for the purchase and distribution of insecticides for use in both the eradication effort and barrier maintenance. MIDA obtains the support of police and other state security agencies in Panama for the enforcement activities and ensures that MIDA field personnel cooperate with the COPEG by reporting infestations and submitting samples of dipterous larvae collected from wounds for identification.

Within MIDA, the National Directorate of Animal Health (*Dirección Nacional de Salud Animal* (DINASA)) has roles and responsibilities similar to APHIS/VS. Within DINASA *Dirección Ejecutiva de Cuarentena Agropecuaria* (Executive Directorate for Agricultural Quarantine or DECA) assists in conducting field surveillance for SW, primarily in the areas of Panama outside the Inspection and Control Zones in Darien Province, DECA also works closely with COPEGs *Control de Movilización de Animales* (Control of Animal Movement or CMA) in animal quarantine activities and the control of animal movements.

Figure 3. Organization chart of MIDA, [<http://www.mida-dinasa.gob.pa/>]



The 1994 Cooperative Agreement between MIDA and USDA for the eradication and prevention of SW was incorporated directly into Panamanian Law No. 13, and was amended in 1999 to support the building of the sterile fly production plant in the Pacora, Panama. Panama has a well developed system of legislative and regulatory support for the SW program, much of it developed for the earlier FMD eradication efforts. Panamanian Law No. 23, (1997 and amended as Law No. 62 in 2002), provides for the zoosanitary authority to support measures for the prevention, diagnosis, investigation, control and eradication of the animal disease, and provides the legal mechanism for quarantine, public health and the environmental protection. Under Panamanian law notification of the veterinary authorities is mandatory for SW.

The authority to establish Control and Inspection Zones used for SW eradication and prevention are also found in regulation used earlier in the FMD eradication program. Law No. 6, dated March 30, 1993, amended Decree No. 121, dated May 12, 1966, that established inspection and control zones in Darien and San Blas (Kuna Yala Indigenous Area) Provinces in the border region with the Colombia. Decree No. 85, dated September 17, 1973, established control and eradication measures for contagious and parasitic diseases of livestock with provisions that allow the National Guard to lend

support when needed in outbreak control and authorizing entry on to the properties of livestock holders. This Decree puts MIDA in charge of the Monitoring Committee to supervise the field veterinarians that carry out COPEG related activities. The legal authority to cooperate with international animal health organizations such as OIRSA (Regional International Organization for Plant Protection and Animal Health or *Organismo Internacional Regional de Sanidad Agropecuaria*) and Pan-American Center of Aftosa Fever (PANAFTOSA) is also provided in this regulation.

USDA

USDA/APHIS has played a very active role in the eradication and prevention of SW in North and Central America. In Panama, USDA has provided extensive financial and scientific resources for the effort as a full participant in COPEG. The Cooperative Agreement specifies that USDA provide one of the two full time COPEG Directors and is responsible for the appointment of 4 of the 8 Committee Members. USDA has cumulatively spent at least 90 million dollars (USD) on SW eradication and prevention in Panama with annual contributions roughly averaging \$5 million USD [8].

The new sterile fly production plant in Pacora, Panama, was completed in 2007 at the cost of \$40 million USD, was funded 90% by the US and 10% by Panama [briefing book]. The ongoing cost of operating the program and the production plant is projected to be between \$7 and 9 million USD annually with funding to maintain at 90% the US and 10% Panama [6].

Discussion: In the Republic of Panama the eradication and prevention of SW has been accomplished through the cooperative efforts of COPEG, MIDA and USDA. Panama has available the necessary legal authority, infrastructure, budget, and supporting resources to carry out the program and maintain their screwworm free status. APHIS could not identify any risk issues associated with this factor that would pose an unacceptable risk to the United States if trade with were to occur.

Disease status in the region

SW eradication in Panama proceeded from west to east. The last case of SW in the Western Region was reported in August of 2000. In 2001 the last case of SW in the Central Provinces of Panama and Colon was reported. However, in early 2003, as the result of the accidental release of fertile flies an outbreak occurred which resulted in 439 cases of SW (discussed further below under Emergency response capacity).

As with previous eradication programs in the other Central American countries, SW eradication in the Republic of Panama was considered to be complete after no reports of SW were made for 6 months in areas outside of the permanent biological barrier at the Darien Gap. In the other Central America countries the successful completion of the SW eradication programs in that country was always accompanied by the implementation of a similar program in the adjacent country to progressively eradicate SW southward from Mexico. Since 1991, the long term goal of the USDA/APHIS eradication plan has been to eradicate SW from all of Central America and to establish a permanent biological barrier in the Darien Gap region of Panama to prevent reinfestation from South America.

Panama is the most southern country in Central America and borders the continent of South America by sharing a border with Colombia. USDA/APHIS considers South America, including Colombia to be endemic for SW and there is no active SW eradication program in place in Colombia. However, since 2003 COPEG has routinely dispersed sterile flies over first 20 nautical miles into Colombia to effectively extend the functional size of the permanent biological barrier into Colombia.

Figure 4. Map of Panama, showing provinces and indigenous areas.



In this regard, the SW status of Panama does not differ from the other North and Central American countries from which SW has been successfully eradicated that bordered on countries where SW was still endemic. In the specific case of Panama the maintenance of the permanent biological barrier serves to mitigate the presence of SW in Colombia and other parts of South America by actively dispersing sterile flies and intensely monitoring for SW reinfestation.

No cases of SW have occurred in Panama outside the biological barrier since 2003 and the number of reported cases within the barrier area has been very low. In both 2004 and 2006 there were only two cases of SW detected within the Inspection Zone and in 2005, COPEG inspectors found 4 positive cases of SW in domestic animals (2 pigs and 2 cattle) in areas within the Inspection Zone. All cases were located within the biological barrier area and very close to the Colombian border. After identification of SW the location is saturated by additional sterile fly release over an area of least 25 by 25 miles. The additional release is done for at least 8 weeks to allow for at least two complete lifecycles of the fly to occur.

The infrequent but continuing identification of SW within the area of the permanent biological barrier, especially in the areas closest to the Colombian border, is an expected

occurrence. The measures in place in the Inspection and Control Zone; including the continued sterile fly dispersal with intensive surveillance and movement controls, are integral to maintaining SW freedom in the rest of Central America. The Inspection and Control Zone activity is designed to detect and prevent the incursion of SW from the South American continent. The identification of these infrequent cases of SW is an indication of the success of the efforts and effectiveness of the permanent biological barrier. The permanent biological barrier will continue to be maintained through the systematic dispersal of sterile flies and intensive monitoring by COPEG [6].

Discussion

The last reported native case of SW outside the permanent biological barrier in the area of the Darien Gap occurred in 2001. The continued, but extremely low, finding of SW within the buffer area adjoining the border with Colombia is an expected occurrence. The established permanent biological barrier and continued intensive surveillance will act to prevent the escape of SW into the rest of Panama and Central America. APHIS could not identify any risks associated with this factor that would pose an unacceptable risk to the United States if trade with Panama in live animals were to occur.

Disease status of adjacent regions

Panama is bordered on the south by the Pacific Ocean and on the north by the Caribbean Sea with a total of 2,490 km of coastline. Panama has a 330 km long land border on the west with Costa Rica and a 225 km border on the east with Colombia. As previously mentioned, SW has been eradicated from Costa Rica but Colombia is still considered to be affected

Cooperative Programs successfully eradicated SW in 1991, Guatemala in 1994, Belize and El Salvador in 1995, Honduras in 1996, Nicaragua in 1998 and Costa Rica in 2000. These eradication efforts were all done through a series of cooperative agreements similar to that supporting COPEG with extensive USDA financial and technical support. The ultimate goal of the USDA Regional Screwworm Plan has been to eradicate SW in all of Central America and to establish a permanent biological barrier to prevent reinfestation from South America

In Colombia, under an initiative of the Republic of Panama and the USDA Regional Screwworm Plan, a number of SW eradication activities have been implemented with the intent of expanding the protection zone beyond the Panama border, into Colombia's Choco region. COPEG is currently dispersing sterile flies 20 nautical miles into Colombia on a routine basis. COPEG officials have also developed training activities to foster the exchange of information from their counterpart in Colombia, the Colombian Agricultural Institute (*Instituto Colombiano Agropecuario* (ICA)), to allow for epidemiological surveillance further into Colombia.

Discussion: The existence of a common land border with a SW-affected region presents a risk for re-introducing SW into Panama from Colombia. However, the work supported by USDA through COPEG to establish and maintain a permanent biological barrier at the Darien Gap serves to mitigate the risk of reinfestation of Panama with SW.

Extent of active disease control program

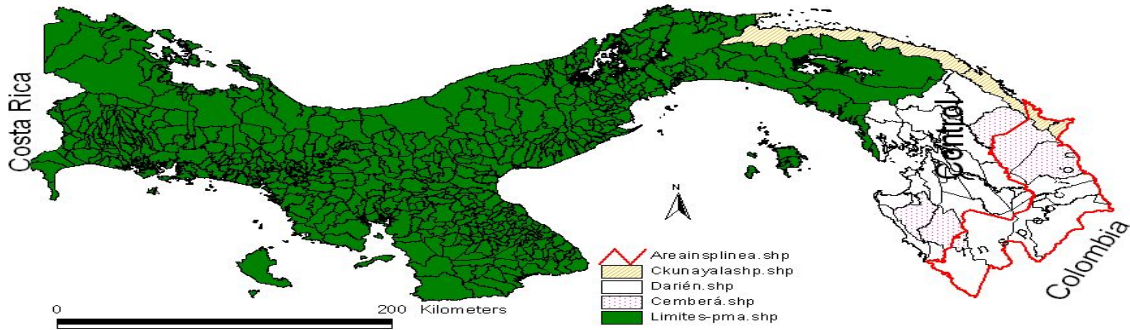
In Panama the eradication program was initiated in 1994 following the signing of the Cooperative Agreement [1]. By 2001, eradication had been accomplished in the western part of Panama and the dispersal area was moved eastward toward the Darién Gap. Establishment of the permanent biological barrier was begun in the Darien Gap area in 2001 by concentrating the dispersal of sterile flies over a smaller area east of the canal and closer to the Colombian border.

The permanent biological barrier established by COPEG includes maintaining Control and Inspection Zones in Darien Province and Kuna Yala to monitor for SW and FMD (see Figure 5). Restrictions established for the FMD eradication program have been in place in this area since 1966. All physical premises in the Control and Inspection Zones are regularly monitored by COPEG personnel, who maintain a census and registry of all livestock and livestock holdings. All domestic animals are subject to movement controls and inspection. Cattle may only leave Darien to move directly to slaughter under formal authorization and may only go directly to slaughter establishments where they are subject to official inspection for both FMD and SW. Swine are limited to those raised for personal consumption.

The Inspection Zone extends from the border with Colombia approximately 40 km into the Province of Darién, including portions of the indigenous areas of Emberá-Wounan and Kuna Yala. In the Inspection Zone the rearing of animals susceptible to FMD is prohibited, with the exception of swine for personal consumption. All holdings with animals within the Inspection Zone are registered and monitored by the regional epidemiologist. The Control Zone encompasses the remainder of the Darien Province and Kuna Yala. In the Control Zone commercial cattle production is minimal and only permitted under regulation.

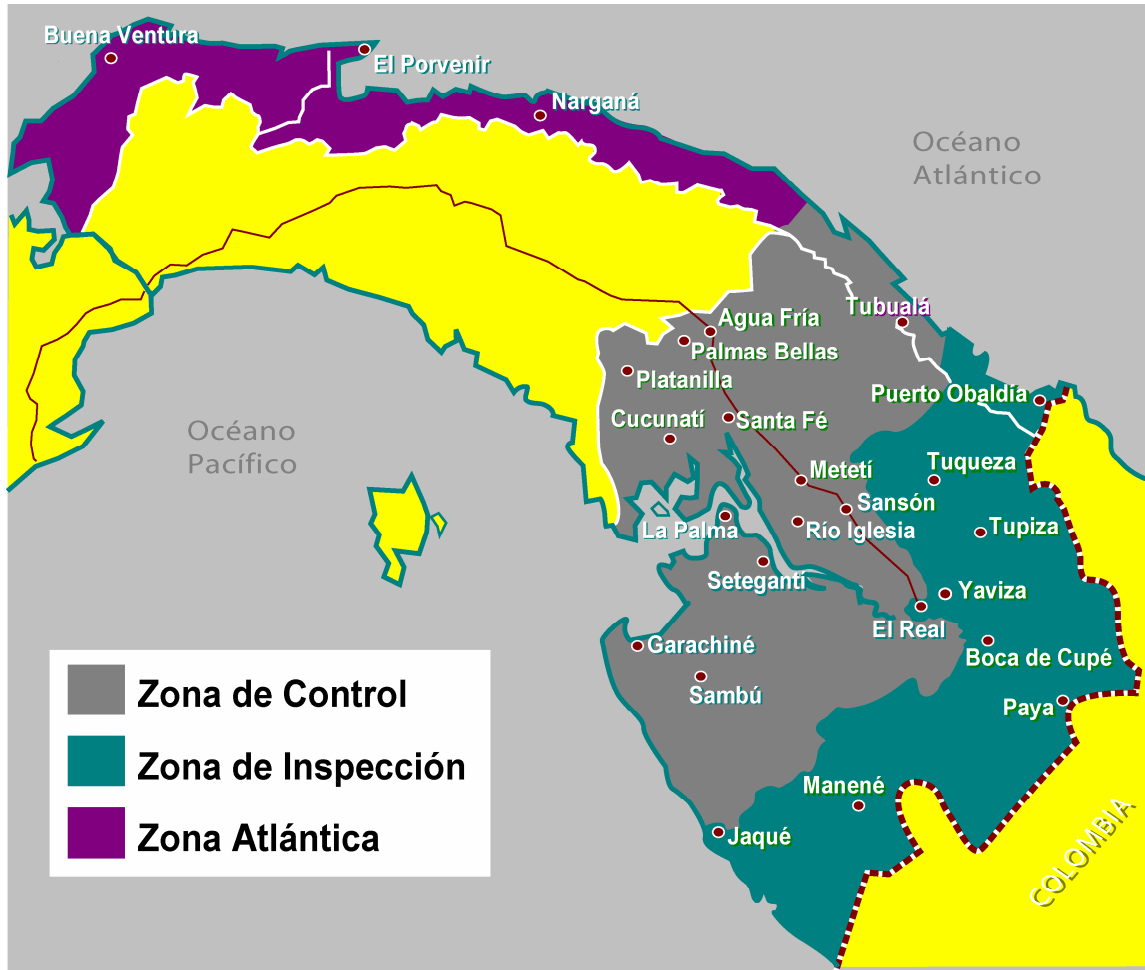
MIDA's Agricultural Quarantine Directorate (DECA), in cooperation with COPEG, employs a staff of 15 inspectors and 1 supervising veterinarian to inspect all animals moved from the province of Darien at 3 movement posts, in Platanilla, Palmas Bellas and Agua Fría [6]. Cattle may only leave Darien to move directly to slaughter under formal authorization and may only go directly to slaughter establishments where they are subject to official inspection for both FMD and SW.

Figure 5. Map of Panama, showing the Province of Darien in white, Kuna Yala Indigenous area in tan. The Inspection Zone is outlined in red. [7]



To conduct disease surveillance in the Inspection and Control Zones, COPEG maintains 19 field surveillance control posts staffed with 53 inspection officers supervised by 3 veterinarians in Darien with additional posts in the Kuna Yala Indigenous Area staffed by 8 officers. The responsibilities of the inspectors include visiting all animal holdings in the Inspection and Control Zones to do animal health monitoring, maintain the animal census, sample suspicious wounds, provide disease awareness training to animal owners, provide wound treatment medication and kits for sample submission by animal owners and issue movement control certificates.

Figure 6. Map of the control posts located in the permanent biological barrier in eastern Panama, indicating the location of the Inspection (turquoise), Control (grey) and Atlantic Zones (purple) with the names and locations of movement controls points [note that Buena Ventura and Sanson are locations for area inspectors]. [8]



To maintain the permanent biological barrier 30-32 million flies are dispersed each week at the rate of 3,000 sterile flies per square mile. Dispersal flights occur 4 days a week, with 3 flights each day with no seasonal variation. Currently an average of 30 to 40 dispersal flights are done each month to maintain the biological barrier [8]. All flights are logged and mapped using a global information system (GIS) to ensure that greater than 90% of the target area is consistently covered on a weekly basis.

During the eradication process the number of flights was substantially higher as a larger area was saturated with sterile flies. The program began in 1998 with 418 flights, increased to 619 in 1999 and reached a high of 1305 in 2000. From 2001 onward, as eradication proceeded from west to east it was possible to decrease the number of flights in the free areas and concentrate the dispersal in the area of the permanent biological barrier. In 2001 there were 859 sterile fly dispersal flights, 623 in 2002, 654 in 2003, 586

in 2004 and 418 in 2006. Flights 20 nautical miles into Colombia began in 2003 and now average 25 to 40 a month for an annual total of more than 400 dispersal flights [8].

Following the positive identification of a SW sample within the barrier area, the location is recorded and more intensive sterile fly release in a grid of at least 25 by 25 miles over the area for at least 8 weeks to cover two SW lifecycles. After detection of SW in the Inspection Zone monitoring of the area by COPEG investigators is also enhanced to alert animal owners of the occurrence of a case of SW and survey for the presence of lesions presenting risk of infestation (navel infection of newborns, natural or surgical wounds, such as castration or dehorning) to increase sampling.

As part of the ongoing prevention program COPEG utilizes approximately 90 full time inspectors in the barrier zone (Darién Gap) of Panama along the Panama-Colombia border to directly monitor animal health, visually inspect and sample for both SW and vesicular diseases. In addition, there are 40 inspectors working in the north and west of Panama in the free zone to monitor livestock for both SW and FMD [6, 7]. The inspectors visit the animal holdings and directly observe the animals for clinical signs of SW and FMD, maintain a census of the number of animal holdings and animals, record the numbers of animals observed for clinical signs of FMD and SW, sample larvae from any suspect wounds and report to the monitoring epidemiologist. Within the Inspection Zone, all animal holdings are visited at least monthly by the local COPEG inspectors. The inspectors also provide sample collection vials to sample suspect larvae from wounds and distribute wound treatment powder (5% Coumaphos, a topical organophosphate insecticide) to treat any open wounds the animal owners may find. All samples, whether taken by the inspector or the animal owner, are submitted for laboratory identification.

Cattle and other species susceptible to FMD or SW may only leave the Darién Province to go directly to an approved slaughterhouse. All susceptible species leaving the control and inspection zones are subject to visual inspection at both the movement control post and at the slaughterhouse. The inspection process involves disembarking the animals to allow visual observation for signs of FMD and SW. Documentation is verified and placement of a sanitary seal on the shipment which is then sent directly to the slaughterhouse. All animals arriving under this seal are subject to mandatory inspection for FMD and SW at slaughter.

The USDA provides the sterile flies from a production facility in Tuxtla Gutierrez, Chiapas, Mexico, until new production plant in Panama begins production. Construction on the Panama Mass Rearing and Research facility was begun in February, 2004, in Pacora, Panama, about 25 miles east of Panama City and construction was completed in July 2007. The new \$40-million, 210-acre facility will house more than 250 employees and has the capacity to produce up to 150 million sterilized flies per week. The new facility incorporates new technology to improve the efficiency of the production process and enhance quality control. USDA's Agricultural Research Service (ARS) Screwworm Research Unit (SRU) will be consolidated from other locations and countries to the Pacora facility to provide continuing research support.

Discussion

Screwworm eradication in Panama was accomplished using the release of sterile fly release method and establishment of a permanent biological barrier that is maintained by continuous distribution of sterile SW flies. The eradication program was the result of the cooperative efforts of USDA and Panama through COPEG. Panama has an active disease control and surveillance program and maintains the permanent biological barrier with continuous distribution of sterile SW flies. SW is a reportable disease in Panama requiring notification of authorities.

Vaccination status of the region

Vaccination is not an applicable control method.

Separation from adjacent regions of higher risk

The Darien Province forms the border between the Republic of Panama and Colombia. This border is characterized by mountainous rainforest on the Panamanian side and flat marsh and swamp on the Colombian side of the border. This area is called the Darien Gap and is roughly 100 miles long and 30 miles wide and is characterized by rocky coasts, mangrove swamps with lowland and upland tropical forests. The remote nature of the Darien Gap was first utilized over 40 years ago in the eradication and control effort for FMD because it serves as a natural barrier to dissemination of infectious diseases such as FMD.

The land supports very little agriculture and is sparsely populated primarily by three Amerindian ethnic groups (Embera, Waunana and Kuna). Much of this border is contained in the National Park Darien which is the largest national park (579,000 Hectares = 2,235 square miles) in Central America. United Nations Educational, Scientific and Cultural Organization (UNESCO) declared the area to be a World Heritage Site in 1981 and a Biosphere Reserve in 1982. There are no major roads crossing the Darien Gap connecting Republic of Panama and Colombia, including the Pan-American Highway which does not cross this area preventing land crossing from Central America to South America. Its natural physical characteristics enhance its effectiveness for creation of the biological barrier explained elsewhere in this document.

Discussion

APHIS finds that the natural and biological barriers of the Darien Gap limit the movement of fertile SW flies or potentially affected animal species from the South American continent into Panama effectively controlling the risk of SW introduction into the Republic of Panama outside of the permanent biological barrier.

Movement controls and biosecurity from higher-risk regions

In the Republic of Panama there is a comprehensive network of movement control posts and 2 quarantine stations managed by COPEGs *Control de Movilización de Animales* (CMA) and MIDA/DECA. Movement control posts are for general animal movement control for FMD, vesicular diseases and SW. All animals passing through these Movement Control Posts are checked for documentation and visually inspected

individually. All wounds are examined, sampled and treated. Animals with suspect wounds may be retained until a diagnosis is confirmed.

Figure 7. Location of COPEG Animal Movement Control Posts (puestos), livestock auctions (subastas) and slaughterhouses (mataderos). [8]



All species potentially affected by SW are visually inspected at the movement control points. More than 500,000 animals have been inspected at control posts in Panama since 2002 (see Table 1). The data from 2003 reflect the increased surveillance efforts involved following the accidental release of sterile flies (see description in the Emergency response capacity section).

Table 1. Annual inspection data for susceptible species passing through control posts in portions of Panama outside the Inspection and Control Zones. [7]

Species	2002	2003	2004	2005	2006	Total
Cattle	66,159	102,006	73,073	72,949	64,432	378,619
Horses	2,998	3,210	1,918	2,173	2,221	12,520
Swine	22,741	23,442	23,320	24,106	7,093	100,702
Sheep	16	1,684	455	319	281	2,755
Goats	118	155	78	181	145	677
Buffalo	0	112	64	48	19	243
Dogs	107	1,658	276	717	218	2,976

Birds	2,241	4,631	4,153	3,902	2,258	17,185
Cats	0	0	0	9	3	12
Rabbits	0	0	0	4	1	5
Other species	0	92	38	17	4	151
Total	94,380	136,990	103,375	104,425	76,675	515,845
Vehicles	5713	44920	27807	47,456	47,168	173064

*source annual reports received 7/23/07

In nearby Kuna Yala Indian Reserve on the north coast (shown in purple as Zona Atlantica in Figure 6) the inspectors and restrictions put in place for FMD eradication have been maintained. In the Zona Atlantica the same restrictions are applied as in the Control Zone of Darien; such that only livestock for personal consumption are kept and all cattle leaving the Darien Province may only go directly to COPEG monitored slaughterhouses where they are subject to inspection. COPEG does surveillance in the Inspection and Control Zones at 19 field surveillance control posts staffed with 53 inspection officers supervised by 3 veterinarians in Darien with additional posts in the Kuna Yala Indigenous Area staffed by 8 officers. Samples from suspicious wounds from the entire country are submitted for positive identification (See Table 2).

Discussion: The movement controls established previously as part of FMD legislation continue to be implemented and enforced by COPEG and MIDA officials. These established movement controls limit the illegal movement of livestock from the Inspection and Control Zones in Darien Province and the Kuna Yala region into the rest of Panama. The continuous monitoring of the permanent biological barrier in the Darien Gap is a strong feature of the cooperative FMD and SW eradication and prevention programs. The system of inspection posts and monitoring throughout Panama significantly limits the risk of introduction and spread of SW in Panama.

Livestock demographics and marketing practices in the region

Panama has a total human population of approximately 3 million with 45% of the populations living in rural areas. More than 70% of Panamanian exports are agricultural products, however, the vast majority of these imports are plant products such as sugar and bananas. Nonetheless, livestock raising (cattle, pigs, and poultry) is an important and long-established economic activity in Panama, and beef and hides are exported. Panama has about 1.5 million head of cattle on 40,000 holdings [9]. Cattle are primarily raised in the southwestern provinces of Chiriquí, Los Santos, and Veraguas. There are 300,000 swine on 28,000 holdings, located primarily in the central and western provinces of Panamá, Los Santos, Chiriquí, and Veraguas. Cattle are only allowed to be raised in the Control Zone area of Darien province where the cattle population density is low and involves roughly 8% of the province, with an estimated 0.9 animals per hectare. In the Inspection Zone area of Darien province commercial cattle rearing is prohibited and agricultural production is limited to swine raised for self-consumption.

The poultry population in Panama is approximately 14 million chickens on 150,000 holdings located primarily in the central provinces of Panamá, Coclé, and Colón. There are an additional 200,000 turkeys, ducks, and geese on 20,000 holdings throughout

Panama as well as a small population of horses and mules (135,000 head on 46,000 holdings), and sheep and goats (12,000 head on 1,000 holdings) [9]. Few SW susceptible live animals are exported.

Discussion: Currently, the export of live animals from Panama is not a large part of the Panama's agricultural economy. SW larvae are not able to survive in non-viable tissue so the importation of meat or other animal products would not pose a risk for introduction of SW into the US.

Disease surveillance in the region

Currently, both active and passive surveillance for SW is conducted throughout all of Panama. Surveillance for SW outside of the Inspection and Control zones is primarily the responsibility of MIDA through DINASA in cooperation with COPEG. In the Inspection and Control Areas of the Darien Province and the Kuna Yala and Emberá - Wounnan tribal reserves in the eastern part of San Blas province, COPEG is directly responsible for conducting surveillance.

Animals are inspected for the presence of SW at Movement Control points throughout the country as well as at slaughterhouses, cattle auctions, fairs and other exhibitions. In 2006, more than 76,000 animals were inspected and more than 17,000 were found to exhibit a total of 25,720 wounds. Each wound was examined and treated. All wounds showing signs of infestation (myiasis) were sampled.

All cattle auctions in Panama are also actively monitored by CMA. In 2006, more than 98,000 animals were inspected, more than 7,000 presented with wounds which were examined and effectively treated. Samples from wounds were submitted for identification, none of which were identified as SW [8]. Auctions were also used as points of contact with animal owners to provide educational information and distribute wound treatment powder.

In both the Inspection and Control areas active surveillance efforts include frequent routine visits by COPEG personnel to all livestock holdings. In the Inspection Zone inspections occur on a monthly basis and in the Control Zone inspections occur at least several times a year. The visits include education about SW and efforts are made to encourage submission of larvae samples from wounds. In 2006 the inspectors did more than 46,000 visits in the Inspection Zone Control Zones [8].

Table 2. Samples submitted for identification between 2002 and 2006, by Province and Comarca. The numbers of positive samples are shown in brackets [7].

Province	2002	2003	2004	2005	2006
Bocas del Toro	9	11	12	9	7
Chiriquí	41	34	23	92	77
Coclé	16	7	6	7	1
Colon	63	71 (27)	34	37	7
Comaraca Emera	7	11 (9)		4	1
Comaraca Kuna Yala	12	10 (3)	8	5	3

Comaraca Ngobe Bugle	5	7	6	6	6
Darien	106 (4)	344 (288)	34 (2)	71 (4)	45 (2)
Herrera	12	13	8	12	10
Los Santos	10	12	14	19	15
Panama	76 (1)	257 (131)	75	76	60
Veraguas	20	25	39	38	19
Total	377 (5)	802 (458)	259 (2)	376 (4)	251 (2)

Samples from suspect wounds were submitted from all sections of the country (see Table 2). The high numbers of samples submitted and found positive in 2003 were the result of an accidental release of fertile flies [see emergency response section] which affected areas outside of the Inspection and Control Zones including the Provinces of Colon and Panama. In 2005, four positive samples taken from two animals (i.e., represent only 2 positive cases) and in 2006 both positive samples were from the same case.

It should be noted that no SW have been identified outside the Inspection and Control Zones in Darien Province since 2002.

Discussion: The infrastructure developed for FMD surveillance has been applied effectively to the SW eradication and control program. The measures in place in the Inspection and Control Zones, which includes the Darien Province and the Emera and Kuna Yala indigenous Comaracas, are adequate to rapidly detect and eradicate SW and prevent the reintroduction of SW into the rest of Panama. Submission of diagnostic samples from all parts of Panama reflects both targeted surveillance within the inspection and control areas and surveillance in the livestock production areas. APHIS finds that the active surveillance program in Panama is sufficient to detect the presence of SW if it were to be reintroduced into Panama

Diagnostic laboratory capacity

The diagnosis of *Cochliomyia hominivorax* may be done by microscopic examination of any of the larvae, pupae or adult stages. All suspect larval samples collected in Panama are sent for microscopic identification to the *Laboratorio de Larvas del Laboratorio de Diagnóstico de Enfermedades Vesiculares* (LADIVES). LADIVES is located in Río Tapia, Tocúmen, Panamá, and was established in 1982 for the FMD eradication and prevention program with the cooperation of MIDA and USDA. LADIVES also serves as the regional diagnostic laboratory for Central America and is a cooperating lab for FAO and OIRSA. LADIVES has Biosecurity Level 3 (BL-3) capabilities and has been ISO certified since 2004 (ISO: 9001-2000). Diagnostic results can be available within 24 hours to allow for rapid implementation of emergency measures if necessary.

COPEG has field personnel trained to take samples and submit them for identification. COPEG also has technically trained identifiers, capable of identifying all the states of SW, in the production facility as part of the Quality Control Department of the Dispersal Center and in other local laboratories. As the SW program reached the end of the eradication phase, the number of suspicious samples submitted to the central laboratory *Cochliomyia hominivorax* has decreased.

Table 3. Samples submitted, by year [7]

Year	Total Samples	Total Negative	Total Positive Samples for <i>Cochliomyia hominivorax</i>
1998	9,927	367	9,560 (96%)
1999	5,743	743	5,000 (87%)
2000	1,094	900	194 (18%)
2001	1,066	1,017	49 (5%)
2002	377	372	5 (1%)
2003	802	344	458 (57%)
2004	259	257	2 (<1%)
2005	376	372	4 (2 cases) (<1%)
2006	247	245	2 (1 case) (<1%)

LADIVES has tracked the species identified in submitted samples since 2000. Seven other species have been identified with some frequency. The majority of these were identified as *Dermatobia homini* (common names- human bot fly, American Warble or Torsalo). In 2005, 178 of the 392 samples submitted were *Dermatobia hominis* and in 2006, 140 of 247. The most frequently identified species are *Phaenicia* spp. (bottle flies; 62 identified 2005 and 67 in 2004) and *Cochliomyia macellaria* (secondary screwworm; 71 were identified in 2005 and 54 in 2004) [7].

Discussion: Laboratory diagnosis of SW in Panama is the responsibility of the central LADIVES laboratory in Toucaman. APHIS considers Panama to have the diagnostic capabilities to adequately diagnose the presence of SW.

Emergency response capacity

Panama has in place a contingency plan for SW outbreaks under the supervision of COPEG. The emergency procedures and implementation is based on the cooperation of COPEG, MIDA/DINASA and the public health agency (National System for Sanitary Emergencies). The contingency plans are supplemented by official instructions and guidelines detailing procedures for disease notification and confirmation, sampling methods, and diagnostic procedures. In compliance with ISO-9001 certification, COPEG keeps their updated emergency plan and manuals on their website.

The emergency procedures are comprehensive and are designed for both SW and FMD. The Emergency Committee (*Comité de Emergencia*) manages the process in consultation with the Director General of COPEG to manage an outbreak on the national level. COPEG secures and allocates the necessary resources, as well as acts as a liaison with local regional animal holdings and the media.

The emergency procedures define the roles and responsibilities of the various supporting agencies for field activities and eradication, including CMA, BPP, FVE and LADIVES. LADIVES provides laboratory support in the area of the outbreak with the capability to immediately report findings to the committee. An epidemiologic investigation is conducted in the affected area under the direction of the Emergency Committee. The directors of BPP and FVE are responsible for the initial activities in the affected zone

including providing trained personnel, supplies, and conducts inspections of all animal holdings within a 5 Km radius of the outbreak.

CMA establishes additional movement control points around the outbreak area and preventive treatment to local livestock. Visits to all animal holding in the affected and surrounding area are conducted to examine animals for the presence of SW, educate the owners as to the presence of SW in the area and distribute treatment and sampling supplies. The fly release/distribution patterns are adjusted by the by the dispersal center (*Centro de Dispersión*) to saturate the surrounding 25 square mile area for a minimum of 6 to 8 weeks to eliminate the presence of fertile SW flies.

The effectiveness of this emergency response was demonstrated in 2003 following the accidental dispersion of fertile flies. Shipments of flies received between January 24 and 26, 2003 from the plant in Chiapas, Mexico, were found to contain roughly one third fertile insects due to a processing failure in the sterilization system. It is useful to note the new plant in Pacora, Panama, will use a more advanced production technology serving and improved quality control thereby decreasing the future likelihood of producing or releasing fertile flies [6].

In response to the accidental release of fertile flies a General Alert was called on January 30, 2003, followed by implementation of the emergency campaign to bring the accidental infestation under control ("Operation Contention 2003"). The General Alert was lifted after the re-infestation was controlled on May 23, 2003. A total of 439 positive cases of SW in livestock were diagnosed during this time period. With the exception of a single case in a goat west of the canal, all the cases were located within the area of accidental release. During the General Alert the emergency plan was implemented with the participation of 190 government officials from a variety of agencies [7].

The area dispersion of sterile flies was greatly extended to contain the outbreak and eradicate the fertile SW. In addition to intensification of release of sterile flies in the area where the accidental release occurred, the area of sterile fly release was temporarily expanded west of the canal into eastern portion of the Province of Coclé and approximately 200 miles into Colombia [7].

Movement control and inspection measures were also increased during the General Alert. Additional emergency check points were added to the existing movement control posts; one near the International Airport at Tocuman and the other in Gatún. During the General Alert 53,803 animals and 18,088 vehicles were inspected. Increased control measures were applied to animals leaving or entering the Control zone in Darién, including increased surveillance of all animals moving to slaughterhouses.

Figure 5. Location of positive screwworm diagnoses during 2003 General Alert (in red). [7]



Visitation efforts were most intensive in the area extending from west of the Panama Canal to the border with Colombia, to alert animal owners of the accidental release of fertile flies and increase surveillance efforts. These visits allowed for additional inspection and sampling, as well as education and treatment efforts. Technical personnel inspected all the properties in the potentially infested area, with over 18,000 visits occurring during the period of the General Alert with additional technical visits during the remainder of 2003. The education efforts included more than 1,500 meetings with animal owners and targeted efforts in mass media with direct promotional materials in potentially infested areas, including, bulletins, posters, pamphlets. General education and dissemination of information was done throughout the entire Republic of Panama as part of the General Alert.

The General Alert lasted a total of 114 days; however, 99% of the positive samples were diagnosed during the first 40 days. This is a good indication of the effectiveness of the surveillance component of the emergency response effort and its rapid implementation. A total of 580 samples submitted during the time of the General Alert of which 438 were positive. The last reported case of SW associated with the fertile fly release was reported on May 19, 2003. Of the 438 positive samples, 280 were from the Province of Darien, 132 from the adjacent Province of Panama and 27 from the Province of Colon, closely reflecting the distribution pattern of the fertile flies. For all of 2003, a total of 797 samples were submitted of which 459 were positive. In the three month period (June-August) following the General Alert, 120 samples were submitted of which only 14 were positive. For the last 4 months of the 2003, 60 additional samples were submitted and only 4 of these were positive.

Table 4. Sample history by month for 2003.

Month	Total	NEG	POS
Jan	39	35	4
Feb	474	56	419
Mar	45	32	13
Apr	20	19	1
May	46	43	3
Jun	35	32	3
Jul	49	40	9
Aug	36	34	2
Sep	18	17	1
Oct	13	13	0
Nov	16	14	2
Dec	9	8	1
2003	802	344	458

During the 2003 outbreak, cattle were the most frequently affected (296 cases or 67%). Swine (82 or 19%), horses (40 or 9%), dogs (16 or 4%) and birds (3 or <1%) were also affected. No human cases were reported. The most frequently affected sites were the navels of newborns (32%), injuries (lacerations and abrasions, 20%) and surgical sites (such as castration and dehorning, 15%) [8]. In 2004 the number of samples submitted remained high as part of the increased surveillance effort. In 2004, the year following the accidental release of fertile flies, a total of 253 samples were submitted with only 2 positively identified as SW, representing less than 1% of samples submitted for the entire year. Both of these positive samples were from the Darien Province.

Discussion: Panama has in place the infrastructure and legal authority to declare an emergency and take appropriate action in case of a SW outbreak. The emergency response capability was proven to be responsive and efficient in 2003 following accidental release of fertile flies. The emergency response plan is comprehensive and allows COPEG to respond rapidly with extensive resources and utilizing the cooperation of several government agencies to rapidly contain and eradicate the accidental infestation. APHIS was unable to identify specific limitations in this system that would pose a risk to the United States.

Release Assessment Conclusions

Based on the preceding assessment of the 11 factors specified in 9 CFR 92.2, APHIS has no evidence that SW currently exists in Panama. SW has not been detected in domestic livestock outside the inspection zone since 2003. Panama’s current surveillance practices for SW are such that an incursion of SW would be recognized and the veterinary infrastructure is well trained and equipped to contain and eliminate an outbreak.

Panama shares a common land border with a region (Colombia) that APHIS does not consider to be free of SW. Unlike previous eradication programs that progressively eradicated SW southward from Mexico and the other Central American countries, SW eradication in the Republic of Panama was not accompanied by the implementation of a

similar program in the adjacent country of Colombia. However, the establishment and maintenance of the permanent biological barrier in the Darien Gap region of Panama serves to limit future incursions of SW from the South American continent which APHIS considers to be endemic for SW. The establishment and maintenance of the permanent biological barrier in the Darien Gap has been the long term goal of the Central American SW eradication program and is designed to identify and control incursions of SW from South America.

The likelihood of introduction of SW into the US is limited to the importation of live animals, as SW larvae survive only in living tissues. Therefore, there is no risk associated with the importation of commodities such as meat or animal byproducts. To pose a risk for US livestock, an infested live animal would have to be imported, with the infestation undetected and untreated, followed by the emergence of viable larvae from the wound followed by burrowing of the larvae in soil, pupate successfully under moderate temperatures, hatch out as fertile adult male and female flies, mate successfully and deposit fertile eggs in the wound of a domestic animal. The management practices associated with the care of animals, specifically wound management, would likely prevent viable larvae from maturing further mitigating the risk of introducing SW in the US.

Live animals imported into the US are subject to inspection at the port of entry (horses in 9CFR93.306, ruminants in 93.408, and swine in 93.507), at which time the presence of larva infested wound would most likely be observed and treated with either topical or systemic agents. In addition, on arrival in the United States horses and swine imported from Panama are subject to quarantine; under 9CFR93.308 horses undergo a seven day quarantine to observe for clinical signs of Venezuelan equine encephalitis and under 9CFR93.507 all swine undergo a 15 day quarantine.

APHIS finds that SW was successfully eradicated in Panama and an effective prevention program is in place through the establishment and maintenance of a permanent biological barrier in the Darien Gap. If SW were reintroduced into the Panama, it would likely be detected and contained before spreading. The maintenance and monitoring of permanent biological barrier the Darien Gap is the responsibility of COPEG, supported by the cooperative efforts of USDA and MIDA. APHIS concludes that the likelihood of SW release into the US to be low.

Exposure Assessment

An exposure assessment as defined by the OIE describes the biological pathway(s) necessary for exposure of animals and a human in an importing country to the hazards released from a given risk source, and estimates the probability of the exposure(s) occurring [12]. Since APHIS' regulatory authority is limited to animal health, the potential risks to animals are the primary focus of this evaluation.

APHIS considers that the most likely pathway of exposure of US cattle and other species susceptible to SW is through contact with infected/infested animals. Other more indirect exposure pathways, such as through animal products, are not likely to result in

infection/infestation because the larvae of the SW do not remain viable in other media except viable flesh.

Imported live animals

APHIS considers the most likely pathway of introduction in the US of SW would be the importation of a live animal infested with SW larvae. However, the survival period of SW larvae in the wounds of live animals is relatively short, approximately 1 week, and SW larvae are readily killed by routine wound management measures.

Following the successful eradication of SW in Panama and the establishment and maintenance of the permanent biological barrier in the Darien Gap adjoining the South American continent, APHIS concluded the likelihood of exposure of susceptible U.S. livestock to SW from infected live animals from Panama to be low. APHIS considers exposure of a susceptible U.S. animal population to illegally imported infected live animals from Panama to be unlikely.

Consequence Assessment

A consequence assessment describes the biologic and economic consequences of introducing the hazards under consideration into the United States. This consequence assessment addresses both direct and indirect consequences as recommended by the OIE [12].

The magnitude of the biologic and economic consequences following an introduction of SW would depend on the location of the introduction, time of the year of introduction, the rate of spread and whether other environmental conditions at the introduction site that might facilitate this spread, ability to detect the disease rapidly, demographics of susceptible species, movement patterns and the ease of employing eradication procedures. Direct consequences include effects of the disease on animal health and the subsequent production losses, the total costs of control and eradication, the effect on the environment, and public health consequences. Indirect consequences including impacts on international trade and associated domestic consequences are not likely to result from an outbreak of SW because of the existing available treatment options.

Animal health consequences

Many animal species, as well as humans, are susceptible to SW. The severity of the disease depends largely on the degree of infestation and health status of the animal, young animals usually more severely affected than older animals. The most serious potential effects of SW introduction would be on the cattle and sheep industries. An Australian estimate done in 2002 found that untreated herds could have 10 to 15 percent of cattle infested at any one time with the greatest source of loss from the death of newborn calves as a result of navel infestation, which can be as high as 30 to 50 percent.

Economic consequences

The overall cost of control and eradication depends on the mitigation or policy option chosen to control and eradicate the disease. Potential costs include disease control

measures such as imposing quarantine measures and movement controls, and direct costs related to treatment of affected and other herds, surveillance and laboratory testing, etc.

APHIS estimates that the U.S. livestock industry benefits of nearly \$900 million a year as a result of the eradication of the SW in the U.S. [6, 14].

In southwest Texas in 1998, a rancher submitted larvae removed from a wound on an Angora goat and one of these larvae was identified as that of a SW by the National Veterinary Services Laboratory (NVSL) in Ames, Iowa. As a result of this diagnosis more than 40,000 head of livestock and dogs were inspected, however, no other indication of SW was found before cold weather eliminated the potential for spread.

In an estimate made in 2002 by Australia it was found that if screw-worm fly were to become established in northern Australia (the only area of the country with an appropriate climate), it could cost more than \$400 million Australian dollars annually in lost production and control measures. Any additional impact on humans, companion animals and wildlife could also result from endemic screw-worm and have serious implications for community health in the north of Australia.

Risk Estimation

Risk estimation consists of integrating the results from the release assessment, exposure assessment, and consequence assessment to produce overall measures of risk associated with the hazards identified at the outset. Thus, risk estimation takes into account the whole risk pathway from hazard identification to the unwanted event [12].

APHIS concludes from the release assessment that there is no evidence that SW currently exists in Panama. APHIS considers the likelihood of introducing SW into the United States from Panama via export of live animals to be low. APHIS concludes from the exposure assessment that the probability of exposure of susceptible US livestock to SW via live animals from Panama is very low. Conversely, APHIS concludes that the animal health and economic consequences of a SW outbreak in the United States could be some consequential because control and eradication measures could be costly depending on the extent of spread and season of the year.

In summary, although a SW outbreak in the United States would be likely to have animal health and economic consequences, APHIS considers the risk of infected live animals entering the US from Panama and exposing US livestock to be low.

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