The Mobile Workshop

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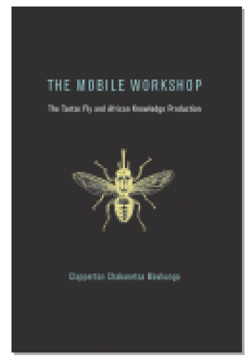

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11 Bombing Flies

The first aerial spraying operations in Africa were conducted in South Africa right after World War II. In 1945, DDT became the first synthetic hydrocarbon *mushonga* to be produced in the Union of South Africa and available for the control of *mhesvi*. The war in Europe had ended. Pilots and *ndege* (fixed-wing aircraft) serving abroad returned home and became surplus to air force requirements, just when the *mpukane* situation in KwaZulu was getting out of hand. No tried and tested method yet existed for applying pesticides using *ndege* (du Toit 1954; du Toit and Kluge 1949).

The first experiment was undertaken in Mkuze Game Reserve, a high-density *mhesvirupani* area, from December 1945 to January 1946. Finely atomized droplets of DDT were sprayed at two- to three-week intervals, resulting in drops in the weekly totals of *mhesvi* caught in the Harris traps from seven thousand to between six and seven hundred per week. The numbers remained constant for three months, and then escalated sharply as the summer progressed. It was clear that six weeks of spraying was adequate to destroy adult *mhesvi*, but too short to destroy those emerging from *zvikukwa* after spraying. The method of application needed improvement—for example, adding course markings to aid navigation, when more than one pilot was involved and *ndege* shared reciprocal parallel boundaries. Finally, the spraying could be more discriminate and based on concrete intelligence about *mhesvi* presence (du Toit 1954, 1959).

An extended campaign in the Umfolozi Game Reserve began in April 1947, covering all permanent breeding areas. The fixed-wing *ndege* failed to access the mountainous and bushy northern parts of Hluhluwe Game Reserve and areas along the western reaches of the Mkuze and Pongola Rivers, however. In 1951, heavier military *ndege* (fixed-wing) gave way to light commercial Piper Aztecs (Cruiser and Super Cub) capable of maneuvering ragged mountain terrain hitherto negotiable only with *zvikopokopo* (helicopters). The operation ended in 1953 with the total eradication of the *mhesvirupani* (du Toit 1959, 237–238).

The Southern Rhodesia aerial campaign against *mpukane* was born in KwaZulu. *Ndege* were adopted for pesticide spraying because of their ease of use, capacity for large-scale coverage, very few personnel required, and capability to reach *mpukane* habitats otherwise inaccessible by ground spraying. State officials in Rhodesia considered that aerial applications of *umuthi* (pesticides) were likely to result in greater environmental contamination than ground spraying. The solution was to reduce the dosage rates and include ambient pesticide-monitoring techniques. Aerial spraying required higher initial financial outlay than ground spraying, but the spraying itself was cheaper than ground spraying per unit area covered, depending on the type of *umuthi* used and the ground sprayed. These savings came from the use of fewer personnel, reduced logistic requirements, and simplified operational planning. Finally, *flymachina* (flying machine, airplane) could take off from and return to airbases in the city for servicing and repairs, whereas it was difficult to do the same with dust-corrupted, bumped and bruised ground-spraying machines in the middle of remote areas. Apparently, this was also the expectation and experience when airplanes were first used in pest-control work in the United States in the 1930s (FAO 1977).

In Southern Rhodesia, aerial spraying developed along two trajectories—namely, nonresidual (beginning in 1948) and residual spraying (1969 onwards). The first method involved the sequential application of tiny droplets of concentrated *mushonga* into savannah woodlands to kill *mhesvirutondo* while they rested in the tree branches or flew around in a panic (Hadaway and Barlow 1965). By contrast, residual spraying—the second method—was simply ground spraying adapted to aerial methods and involved spraying *mhesvi* in their habitat, leaving a residue that killed them through skin contact long afterward. This method was favored particularly for riverine vegetation, drainage lines, and *ecotones* (areas where two vegetational communities converged; FAO 1977).

Southern Rhodesia's aerial spraying began in 1950 when Dr. Rene du Toit, subdirector of the Union's Division of Veterinary Services at Onderstepoort, visited Southern Rhodesia to advise staff on the application of *mishonga* from *ndege*. Chorley secured a *ndege* from the Southern Rhodesia Air Force for a reconnaissance flight over Hurungwe District.[1]

In 1951, a master plan was drawn up for "a large field-scale experiment using *ndege* for the application of insecticide in aerosol form."[2] The operations only began on November 30 the following year, when the rainy season was under way, and they continued through the end of March 1953. The

South African contractor and the pilots that flew the three planes involved brought to Rhodesia vast experience from KwaZulu. The techniques were also based on this prior experience; their opinions were "accepted without any preliminary experimental work."[3]

The spray area was chosen because it was where *mhesvi* congregated during the dry season. It lay between the lower Msukwe and Badze Rivers, just west of Hurungwe—"a natural line of dispersal into the reserve"—as well as into the white-owned Karoi Block. Detailed tests were conducted to determine aerosol behavior under different temperatures, wind, and other conditions. Du Toit had originally planned for six applications at twenty-eight-day intervals; in practice, it was discovered that three planes could cover the originally targeted area in just fourteen days. Therefore, the area was widened to include the Rongatutu River system to the north, and the spraying cycle was reduced from twenty-eight to fourteen days.[4]

The heavy rains made communications a nightmare. Wireless signals were initiated, but contact between the pilots and the aerodrome "could not be made before the aircraft took off at dawn." The coordination between the pilots flying and spraying above and the flyround teams measuring the effectiveness of the spraying below proved tenuous, the aerosol coverage—and kills—uneven. The "kill" on the Msukwe-Badze system was "reasonably satisfactory," that on the Rongatutu "poor." This unevenness in results was attributed to the difference in vegetation and poor pilot ground observations due to the heavy rains. The director, Du Toit, and the general manager of the South African spraying company visited the area and decided to suspend operations in late March until the rains had subsided.[5]

In the 1953–1954 operational year, in cooperation with the Departments of Civil Aviation and Irrigation, an airstrip (see figure 11.1) was constructed at Zvipani with *vatema* commandeered by the Native Commissioner.[6] From this advanced airstrip, two to three sorties could be conducted every day, taking off and landing, refueling and replenishing *mishonga* supplies, thus eliminating the dead time that existed previously when fixed-wing *ndege* had to return to Salisbury to perform such tasks.[7]

The spraying operations started in early July 1954 with the objective of covering all the river systems and dry-season concentration areas of *mhesvi* between the Badze and Kanyati Rivers. During the first cycle, the planes, taking the Badze as their starting point, failed to reach their target, the Kanyati; subsequent sorties had to be abandoned.[8]

By the end of September, only the original Badze-Msukwe area had been covered. Meteorological conditions were worsening with every subsequent

Figure 11.1
Airstrips like these were used for speeding up operations by creating a field base for fuel and ammunition supplies and for landing and taking off without having to return to urban-based airports. The picture shows insecticide drums (foreground) and fuel.
Source: Allsopp 1990.

cycle. In the hot, dry season, the high winds in the morning and the heat-induced atmospheric turbulence made flying and the control of aerosol discharge impossible.[9] The operations doddered for two more months, but by the end of November conditions had deteriorated beyond flight safety. The operation was abandoned.[10]

As this chapter will now show, these operations were only the beginning. For the rest of the century, BTTC airborne operations would become more sophisticated and dynamic. This chapter will discuss the technical aspects of aerial spraying, treating them as an example of the extension of means and ways designed in the United States for agricultural or military purposes to deal with a *chipukanana* and conditions for which they were not originally designed. It will focus on fixed-wing *ndege* first and then turn to *zvikopokopo*. Figure 6.1 shows all the areas in Rhodesia mentioned in this chapter. The glossary at the back of the book will aid in the understanding of *chidzimbahwe* and other local keywords.

The Tiger Moth and Avro Anson XIX: Kariba, 1955–1956

In the 1955–1956 operational season, plans were drawn up to conduct "block application" and "linear application" to areas adjacent to the township of Kariba and outlying rivers, respectively. The aerial spraying target was an eight-square-mile area including the Kasese River, the main access road, and the township. Eight applications were scheduled, involving a 4 percent BHC solution mixed in diesoline (to make it stick to and penetrate target) sprayed at an average rate of 0.1 gallons per acre. The operations were scheduled to begin on May 1, 1955. A local contractor, Messrs. Skyworks (Pvt.) Ltd., was hired to do the job, with four Tiger Moth *ndege* powered by Gipsy Major Series I engines and each bird carrying a fifty-gallon tank of *mushonga* (see figure 11.2).[11]

The de Havilland Tiger Moth was a 1930s biplane named after its designer, Geoffrey de Haviland, and a product of de Havilland Aircraft Company (UK), which saw service in the UK Royal Air Force until 1952. Following the adoption of the de Havilland Chipmunk as the preferred primary trainer, the Tiger Moth became excess ordnance and was decommissioned for civilian

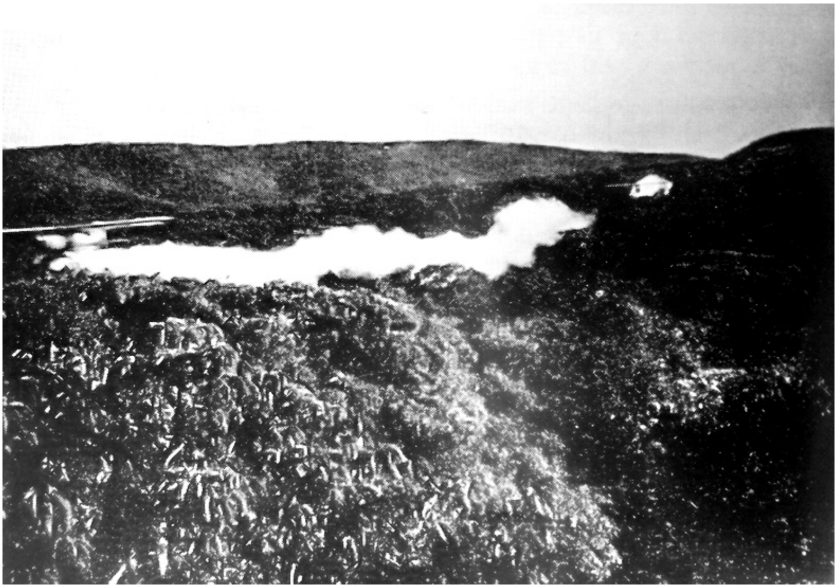


Figure 11.2
Two fixed-wing *ndege* on an aerial-spraying pass over northern districts.
Source: Proceedings and Transactions of the Rhodesia Science Association 1960.

use. The Tiger Moth itself had retired the de Havilland Gipsy Moth which had made its maiden flight in 1931 in response to the British Air Ministry's request for a *ndege* with a more accessible cockpit. It was standard training procedure that the front seat occupant of this bird must have ease of escape with a parachute strapped on in case it was going down. The Gipsy Moth's fuel tank was directly above and severely limited access to the front cockpit (Hotson 1983; Bain 1992). By contrast, the Tiger Moth was powered by the Gipsy Major, a four-cylinder, air-cooled, inline engine, standard for 1930s light *ndege*. Its cylinder pointed downward under the crankcase, thus keeping the propeller shaft in high position, so that the cylinders steered clear of the pilot's view past the bird's nose. Early on, the *ndege* consumed too much oil, and the tank (located outside) needed constant refueling, forcing frequent landing and takeoff. To remedy the problem, the piston rings were simply modified (Bransom 2005).

In the 1955–1956 operations, the Tiger Moth was mounted with fifty-gallon tanks of 4 percent BHC solution in diesoline, delivered by electric pumps to the exhaust stacks. The droplet sizes of aerosol emitted from the exhaust stacks were tested and adjustments made to spray nozzle sizes until the required size was achieved. The spray unit was then standardized so that the nozzle size was set for this type of *ndege*. In several sorties, tests were repeated on the droplet size and aerosol delivery rate, using magnesium oxide plates as indicators of droplet size.[12] Unlike in 1953–1954, the 1955–1956 operations went smoothly throughout the entire eight-cycle spray routine thanks to a prolonged spell of suitable weather conditions. The wet season had gone on longer than normal, and leaf fall had been delayed, allowing the completion of the eighth spraying cycle before *mhesvi* had concentrated in the riverine vegetation.

Also in action over Kariba in the 1955–1956 operation was another British exmilitary *ndege*, the twin-engined Avro Anson XIX, again operated by Skyworks. This *ndege*, named after British admiral George Anson, made its maiden flight in 1935. Avro was a British *ndege* maker established in 1910 in Manchester but based in Lancashire; its birds saw action in both world wars and in the Cold War—the trainer Avro 594 in World War I, the Avro Lancaster in World War II, and the Avro Vulcan in the Cold War. *Avro* is an acronym formed from the name of the company founder, Alliott Verdon Roe. The company initially was called A. V. Roe and Company. The Avro Anson was designed for maritime reconnaissance, only to prove virtually worthless in that role, so it was redeployed as a multiengine aircrew trainer instead. The earlier version of the Anson, the Mark I, had a wooden wing made of spruce and plywood and a fuselage made of steel tubing wrapped in fabric, and the nose of the *ndege* was coated with magnesium alloy. Two Armstrong Siddeley Cheetah IX seven-cylinder, air-cooled radial engines, each with 350 horsepower (260 kW), powered the *ndege*. In its maritime recce role, the Anson had a three-man (later four-man) crew composed of the pilot, navigator or bomb-aimer, and radio-operator or gunner. Its wings could carry 360 lbs. worth of payload, whereas the front fuselage had fixed Vickers machine guns dashboard-operated by the pilot. In addition, the gunner operated another machine gun mounted on a turret (Holmes 2004; Jackson 1965). By the time the Anson was discontinued in 1952, 11,020 birds had been manufactured.

What changed? Spray nozzles replaced gun barrels. The Avro Anson XIX *ndege* was powered by two Cheetah XIX engines loaded with two one-hundred-gallon tanks of 4 percent gamma BHC in diesoline. The *mushonga* was introduced into the *ndege*'s exhaust stacks using electrically driven impeller-type pumps to produce the aerosol.[13] By 1955, the *ndege*'s spray system had already experienced several innovations.

In the first East Africa trials of the 1940s, Avro Anson XIX *ndege* were fitted with four fifty-gallon spray tanks. They were fitted in such a way that the spray came out through gravitation force from two wide pipes extending some thirty-five centimeters below the *ndege*'s fuselage. At the end of each pipe was an Iris diaphragm to adjust the emission rate of the spray. The pilot could make these adjustments in flight. To atomize the spray, the pilot worked with the slipstream to break up the liquid coming out of the pipe into spray droplets. However, too many droplet size options often presented problems of evenness and effectiveness, and this spraying system was subsequently terminated (FAO 1977).

Another early spraying method of the 1940s, first tried in South Africa and Kenya, was to turn the Avro Anson's thermal exhaust into a spraying machine. This method simply involved letting *mushonga* move down into the exhaust system through a narrow pipe, so that it was then emitted in an upright position down into the slipstream thirty centimeters below the rear edge of the *ndege*'s wing (du Toit 1954). Meanwhile in Kenya and Tanganyika, major advances in air-to-ground and air-to-air insect spraying were achieved against locust swarms (Gunn et al. 1948a, b).

Entomologist R. J. Phelps oversaw the Southern Rhodesia operation. From May to September 1957, Phelps's job was to standardize the dosage rate and droplet size, decide when and where to spray, and record the *mushonga*'s effects on the *mhesvi* population. The workday started at four in the morning and ended at about ten o'clock in the night, the planes taking off whenever weather conditions allowed.[14]

Terrain preordained the complementary deployment of the Tiger Moth and the Avro Anson in Kariba. The two were intended to spray the flat areas, flying at 120 miles per hour over a swath seventy-yards wide, each bird dumping one gallon of *mushonga* in 27.6 seconds. The Tiger Moth, meanwhile, was assigned to the more rugged country and along the riverine fringes, flying at about 80 mph and with a twenty-five-yard swath. Each *shiri* discharged one gallon of *mushonga* in 62.5 seconds. Aside from the terrain, there was a problem of far-from-ideal weather conditions, characterized by very strong northeasterly winds that restricted the amount of flying time available.[15]

The spraying operation was divided into a twenty-one-day cycle, which was the standard for treatment, corresponding to the breeding cycle of *mhesvi*. The weather had other ideas, and the cycle was accomplished only once, with the effect that "a female larva deposited immediately before an application of *mushonga* could mature, become adult and mate, but would encounter an application of *mushonga* before dropping its first larva."[16] The aerial sprays were sustained for 135 days, enough time to cover the phase of *zvikukwa* deposited prior to spraying.

In all, spraying constituted just 8.5 percent of the Tiger Moths' flying time and 35 percent of the Avros'. The low efficiency was not blamed "on pilots or ground crews, who exhibited great skill and patience at all times, but [was] an indication of the difficulty of flying along the narrower river courses," of time lost while maneuvering the *ndege* after making a spray run, and of "obsolete aircraft."[17]

Overall, the treatment was declared a success. The valley floor application had been effective, even though the Chikomba vlei traverse had shown that the linear treatment was unreliable for achieving satisfactory kills from May to September. At 14s. 22d. per acre for six applications, including *mushonga* and hiring the *ndege*, it was less than half the cost of the Kariba aerial spraying, in which ten applications were made.[18] Even after the Tsetse Branch felt that its shift was done, the Federal Power Board, concerned about the impact of *mhesvi* and *n'gana* on the construction crews building the Kariba dam and power station, continued the operations for a further three cycles, focusing on the riverine vegetation.[19]

To do this, more *mushonga* supplies were required instantaneously. The South African company Klipfontein Organic Products undertook to send the concentrated BHC solution by railroad in three days to Kariba. Further delays in transport meant that breaks occurred between the application cycles, and when the ninth, tenth, and eleventh cycles were finally deposited on the riverine vegetation, the trees were already in leaf and *mhesvi* made good its escape. Still, the objective of the spray was achieved within the budget, and by 1956 the acting director concluded that the concentrations of *mhesvi* between the Kasese River and the Kariba Gorge construction site had been vanquished—barring the upper headwaters, where the vegetation was too dense and flying conditions too severe for effective aerosol application. Still, along the riverine thickets of the Chavaru and Nyanyanya Rivers seven and nine miles from the construction site, *mhesvi* had been reduced only, far from eliminated.[20]

The 1955–1956 aerial-spraying operations at Kariba ended in late October 1956 on a high note. Subsequently, flyrounds were maintained throughout the year to keep *mhesvi* under surveillance, track its postspraying behavior, and respond according to the intelligence gathered. As expected, right after the treatment was concluded, a rapid buildup of *mhesvi* threatened to overrun the sprayed areas from the unsprayed ones nearby. The recovery in the *mhesvi* population of the sprayed area from the Kasese River eastward was swift; between that river and Kariba township, however, there were no *mhesvi*. At the dam construction site and Nyamhunga township, *gopé* (sleeping sickness) was recorded in *imbwa*, but none in *vanhu*.[21]

The aerial spraying succeeded in significantly reducing the *mhesvi* population based on pre- and post-treatment catches, only for the numbers to build up rapidly again, exceeding the pre-spray figures. The entomologists concluded this was due to immigrants from untreated areas following *mhuka* now roaming freely after the removal of *vatema* who had hunted them to make way for the Kariba dam, especially in the Kasese River area. Overall, the aerial spraying had reduced the *mhesvi* population in the dam site area and averted an impending sleeping sickness hazard to workers. As the waters began to fill the entire area, *mhuka* would either drown en masse and die or flee to small islands, severely limiting *mhesvi*'s food source and transport. Such habitat was being systematically destroyed, the bush sprayed; the *chipukanana* would have nowhere to hide from the air and ground assault.[22]

On one point, entomologist Rawdon Goodier was clear. The aerial spray over Kariba left more questions than definitive answers:

> There has been a rapid reinvasion of tsetse from the surrounding infested country, at a rate that was foreseen. It is now evident that to have achieved elimination of tsetse between the Nyanyanya River and the dam site, and to have maintained it free for a period of 18 months, it would have been necessary to treat a far larger area. How much larger the area would have had to have been to achieve the desired result one can only guess but it may well be something in the region of at least five times the block spray area and probably considerably greater. Riverine spraying alone must be

considered unsatisfactory as the concentration of tsetse on the rivers cannot be relied upon for more than a brief period and this period occurs at a time when weather conditions are far from ideal for spraying.[23]

The Piper Aztec (PA-23 Pawnee): The 1974–1975 and 1982 Operations

In 1974, a twin-engine Piper Aztec *ndege* fitted with a single Micronair spray system was used to spray the Chirisa Game Reserve in Gokwe, having been successfully used in clearing *mhesvi*-infested areas of the Okavango Delta of Botswana the previous year (Kendrick and Alsop 1974; Lee et al. 1975; Chapman 1976). Also called the Piper PA-23 or simply the Apache or the Aztec, this *ndege* was a four- to six-seater twin engine initially designed by Stinson Aircraft Company of Dayton, Ohio. The company was established in 1920 by Edward Stinson and later moved the bulk of its operations to Detroit, Michigan, under the name Stinson Aircraft Syndicate. The site of its factory was what is now Detroit Metropolitan Wayne County Airport (established 1920). After World War II, Stinson Aircraft Corporation entered into several buyouts by bigger corporations, eventually being sold to the Piper Aircraft Corporation in 1950. It was at this point that first the Piper Apache and then the more formidable Piper Aztec entered the scene. These four- to six-seater twin-engine light *ndege* were designed for the US Navy and for air forces of friendly countries as late as the 1980s. When Piper acquired Stinson's Consolidated Vultee Aircraft Corporation, it also took over the latter's Twin Stinson design and developed the Piper Apache (later Piper Aztec) 23 (PA-23). On its test flight in 1952, the *ndege* was a four-seater, low-wing, all-metal monoplane equipped with two Lycoming O-290-D piston (125 horsepower) engines. It failed the test, prompting a new design with a single vertical stabilizer, all-metal rear fuselage, and 150 horsepower engine in 1953 (Peperell and Smith 1987).

Designed for agricultural purposes, the PA-25 Pawnee became (along with the Cessna) the signature aerial insecticide spraying *ndege* throughout the world, including Africa, from 1959 to the 1980s. Before 1949, the bulk of *ndege* deployed for agricultural purposes in the United States were retrofitted military birds, but in 1949, Fred Weick of Texas A&M University designed the AG-1, dedicated specifically to agricultural spraying purposes. The following year, the bird successfully completed trials. In 1953, Piper made Weick its consultant on a project to create an agricultural version of the PA-1 capable of distributing pesticide dust and seed; that is how the PA-18A was born. Another Piper grant later, Texas A&M developed the AG-3, a fusion of compatible AG-1, PA-18A, and PA-22 elements.

Smaller than the AG-1, with steel-tube fuselage, fabric covered, this single-seater, low-wing monoplane was equipped with conventional landing gear, a tailwheel, a 135-horsepower engine, and an 800 lb. capacity hopper in front of the cockpit. The pilot's high seat in the fuselage allowed for clear visibility. The bird was tested successfully in 1957 and was renamed the PA-25 Pawnee, now outfitted with a 150-horsepower Lycoming O-320-A1A engine. Other generations of the Pawnee followed (Peperell and Smith 1987). Today, its design rights and technical support are (since 1988) owned by Argentina's Latino Americana de Aviación, again showing the Global Southernization of companies or their artifacts (Peperell and Smith 1987).

The 1974 operations over Chirisa Game Reverse were conducted using an ex-military PA-23 and intended to spray endosulfan (thiodan) at a strength of 20 percent active ingredient. These were small-scale spraying trials, not synchronized or mutually complementary to adjacent ground-spraying operations.[24] The *mushonga* was delivered at 5.62 liters per minute to a wind-operated Micronair AU 3000 rotary atomizer fitted to the wing of a twin-engine Aztec *ndege* operated at 8,500 revolutions per minute. The *ndege* flew at 150 miles per hour and twenty-five to thirty meters above the ground (treetop level), depositing swaths of *mushonga* at two-hundred-meter intervals over 130 square miles. Judging the prevailing wind direction was important to accurately predict wind drift relative to the positioning of the spray. The start and end points were clearly marked with pencil flares and twelve-volt spotlights operated from roads or other features visible from the air. The best time to use aerosols was when the *mhesvi* was at the *chikukwa* and *chiguraura* stages of its life cycle.[25]

The spraying campaign may have knocked back the *mhesvi* population in the experimental area, but it failed to attain the objective of eradicating the *chipukanana* in the spray area. Just why this was the case was not certain, but one explanation may have been that the spray area covered was too small relative to possibilities of reinvasion. Another reason may have been that the concentration of *mushonga* was insufficient to achieve a total—or at least effective—kill of all the adult female flies, especially *mhesvirupani*. Overall, the method was found to be impractical and inefficient, and further trials were ordered in 1975 just to be sure.[26]

The Tsetse Branch now cleared a 732 km^2 area inside Chirisa Game Reserve for the new trials. The purpose of the spray was to "reduce the probability of rapid invasion"; to achieve this, the two-hundred-meter swath was doubled. To cater to the rough terrain, the maneuverable single-engine Pawnee was used in place of the Aztec. The spraying was conducted at night, except in the more broken terrain, which was sprayed in the morning and early evening to capitalize on daylight. Small flares and lights were replaced with "a very bright light (adapted from a photoflash unit) flashing every 3-5 sec and carried up to 200m by a hydrogen-filled meteorological balloon," itself "raised or lowered rapidly with a rod and reel and … transported between marker stations in a protective cage fixed behind a Land Rover." The speed of the Micronair atomizer was increased to 10,000 revolutions per minute (rpm) to reduce spray droplet sizes. It had been found that the smaller the droplets were, the more effective the spray was because "the small appendages of the flies collected such droplets."[27]

The spray area was divided into a central region and a perimeter region. The central region was subjected to intensive spraying of 70 percent solution applied in swaths 200 meters apart to monitor the effects of *mushonga*. The perimeter region was treated at half the rate (35 percent applied in swaths 400 meters apart) as a perimeter "fence" to protect the central region against reinvasion from the surrounding bush. The core area was divided in two again, with one section given a 20 percent thiodan treatment, the other 25 percent thiodan. The operation started on July 10 and terminated on September 19. Five applications of *mushonga* at intervals of nineteen, nineteen, sixteen, and thirteen days were deposited, making the most effective use of the first deposition of *zviguraura* and late phases of *zvikukwa*. Very good tsetse control was accomplished overall.[28]

In 1982, BTTC started a program of postwar aerial-spraying operations to arrest the advance of *mhesvi* in the Zambezi valley area of Gokwe and Sebungwe adjacent to Lake Kariba. Later, the operations moved northeast along the shoreline, the idea being that the lake was a hydro-defensive shield against a *mhesvi* invasion (Allsop 1991, 7). The 1982 operation in Sengwa and Sesami was a combination, for the very first time, of ultralow volume (ULV), nonresidual aerial spraying and normal 5 percent DDT suspension ground spraying to address a rapidly deteriorating *mhesvi* situation in Gokwe. The Department of Veterinary Services engaged the services of a contractor, Messrs. Agricair (Pvt) Ltd. of Harare, and used thiodan (endosulfan) made by Hoechst, Zimbabwe (Pvt) Ltd. Two Piper Aztecs and a Turbo Thrush were used. The latter was a low-wing, single-seater monoplane specifically designed for agricultural purposes by Leland Snow and flown first in 1956. It was manufactured by Ayres Corporation of Georgia in the United States. The turboprop engine was a 1980s development, prior to which the Thrush had been powered by a radial piston engine (Green 1964; Simpson 2005).

The differences and similarities between the two planes are important. The Thrush was a conventional crop sprayer; the Aztecs were originally designed as light twin-engine military personnel carriers and were thus modified to carry *mushonga* and navigation equipment. The Thrush was virtually brand-new—the latest means there was on the market. The Aztecs, by contrast, were old birds, "and this together with the fact that they were being used outside their designer's intentions generated a lot of technical problems." The crop sprayer was designed for navigation at night, when meteorological conditions "favoured the sinking of near weightless micro-droplets down into the woodland."[29] The terrain too was difficult: escarpments and plateaus like Domwe Hill required that pilots climb steeply from treetop height to around two-hundred to one thousand meters before reaching the clear sky above them. The turbo-charged Thrush could do this without any problem; not so the lumbering Aztecs, which had to commence the climb in good time. To aid night vision, the obstructions were marked clearly with flashing strobe lights inserted by a Bell 47 helicopter (*chikopokopo*) a day earlier. Premarked baselines also guided the *ndege*'s direction of flight and spray. Each *shiri* was also fitted with a track-guidance system to allow parallel runs.[30]

The mission of the Aztec was clear: to penetrate and spray areas of the drainages inaccessible on foot, extend the area targeted for treatment, and "give the operation greater depth."[31] The combined strategy required commencing the ground spraying well before the Aztecs took off to give the DDT enough time to take effect. This ensured that the adult flies were killed in the areas surrounding the vleis or river lines targeted for aerial spraying; if any were present, they would move in and deposit *zviguraura* after the planes sprayed the first cycle. Subsequent cycles were intended to cover just one *chikukwa* period, and females invading between cycles would deposit their *zviguraura* in time for them to hatch after the fifth and final aerial treatment, thus rendering the entire effort null.

The operations began on the night of July 27, 1982, and were completed without incident by the end of September. Between 14.7 and 25 grams of active ingredient were deposited per hectare from the air. The droplet pattern each *ndege* emitted was established by collections of droplets on rotating magnesium oxide–coated glass slides before and after the spraying, with each night's work monitored by droplet collections and by three mobile ground teams. Total eradication was achieved: Not a single female adult *mhesvi* was caught; all flies caught were recently hatched. The young females dissected showed a severely disrupted mating or insemination due to residual effect, thus achieving delayed reproduction and buying *mhesvi* operations more time.[32] The only drawback was the loss of twenty-nine atomizers that broke, burned out, or simply dropped off in flight, severely hampering the free flow of operations (Allsopp and Hursey 1986, 34).

The 1983 operation was a continuation of the 1982 combined air and ground attack, the objective being to drive *mhesvi* toward Lake Kariba, this time targeting the area between the Chizarira escarpment and the shoreline. The 1982 operations had concentrated on the Simchembu *mhesvi* refuge; those of 1983 focused on a 2,100 km^2 area of Binga, with no prominent features, yet still rugged, undulating terrain that worsened as the planes headed east. The gorges of the Rwizirukuru River valley marking the eastern edge of the spray area were quite steep, thus making the topographical conditions in 1983 much like those of the previous year. Unlike in 1982, however, the first cycle spray used deltamethrin in diesoline solvent at 0.25 g/ha, as per an agreement between the Tsetse Branch and Wellcome, which was testing the insecticide as a possible alternative to DDT. The *mushonga* made "a respectable reduction" in *mhesvi* but did not achieve 100 percent success. The failure to eliminate *mhesvi* from the Rwizirukuru valley was attributed not just to deltamethrin, or subsequently endosulfan, but was an indictment of fixed-wing aerial spraying as a method in general (Hursey and Allsopp 1984).

The Cessna 401 in the Chizarira and Matusadona Operations: 1984–1988

The third fixed-wing *ndege* deployed in Rhodesia was the Cessna, in its several varieties. Elsewhere in Africa, the Cessna 180 and 310 were used (Lee 1969; Lee and Miller 1966; Baldry 1971; Lee et al. 1975; Lee, Pope, and Bowles 1977; Park et al. 1972; Hocking et al. 1966). Our focus here is on the Cessna 401 used in spraying the Chizarira escarpment near Kariba in 1984, four years after independence. The *ndege* was manufactured by Cessna Aircraft Company, a US general aviation aircraft-manufacturing corporation based in Wichita, Kansas (Phillips 1986). The 1984 aerial spraying operation in Chizarira was conducted using two such turboprop-powered Cessna 401s.

With its distinctive four small oval windows, the six- to ten-seater, light-twin, piston engine Cessna 401 was one of the business jets named Businessliner or Utiliner that Cessna had been making since 1966 with affordability as a key selling point. The seats were detachable, and the *ndege* could be used for other utility purposes—hence the name Utiliner. Cessna 401s and 402s were nonpressurized and rather slow in speed, being powered by three-hundred-horsepower turbo-charged Continental engines with three-bladed, constant speed, fully feathering propellers. Models built from 1966 onwards were limited to 75 percent cruise power, and some were fitted with propeller synchrophasers to reduce cabin noise. The turboprop-powered conversion of the *ndege* began in 1969, with the objective of increasing fuel tank capacity, gross weight, and speed control; it was completed in 1974 (Plane and Pilot 1978; Montgomery and Foster 1992). Two such turbo-propelled engines were involved in the 1984 campaign.

The two fixed-wing *ndege* covered 1,700 km^2 north of the Chizarira escarpment, stretching west toward Mcheni River and the Ume to the east. Accurate aircraft navigation relied on Decca Doppler equipment connected to a tactical air navigation system (TACAN) computer, complemented by three ground-based "marker parties" using ground-to-air radios, 15 mm signaling flares, and elevated flashing beacons. This method was used in the previous operation; it worked "satisfactorily." The pesticide was sprayed through wind-driven Micronair AU 5000 atomizers attached to the fuselage, behind and below the wing, with the pesticide drawn from tanks suspended beneath the fuselage.[33] Thiodan was to be applied in five-cycle sequences at dosage rates of twenty-five, eighteen, fourteen, fourteen, and fourteen grams per hectare. The results were inconclusive "because of the inability to determine whether the old flies captured … survived treatments or had immigrated from the surrounding ground sprayed area."[34]

The blame for the failure of the 1984 operation was placed partly on the almost total absence of localized night winds, which made droplets fall directly down instead of sweeping sideways to penetrate *mhesvi* hideouts between cracks in the bark or underneath leaves and logs. This is where ground spraying excelled, so the teams swept in (Allsopp and Hursey, 1986; Allsop 1991, 8). Even after the dosage strength was increased from 14 g/ha to 18 g/ha for cycles 4 and 5, a low-density residual population of *mhesvi* still remained. In fact, the combined operation was even less successful than those in 1982 and 1983, and a Bell 206 *chikopokopo* had to be brought in to re-treat the Umi valley (Allsopp and Hursey 1986, 16–17).

Several theories were put forth to explain the failure; they reemphasize what happens at the site of encounter between incoming things and local conditions. They are significant because the 1985 aerial campaign was designed to test those hypotheses. One was that the population of *zvikukwa* was too dense and so too were the emerging flies after application cycles 1 and 2; thereafter, there was faster contact and thus mating between male and female. The post-ovulation speed of *zviguraura* development was contingent upon prevailing temperatures: faster if warmer, slower if cooler

(Allsopp and Hursey 1986, 15). The campaign had been delayed, and the closing cycles of spraying had coincided with rising August–September temperatures (23°C–25.4°C) as the southern African summer beckoned. Thus, the cocktail of rapid ovulation and faster development of *zviguraura* unleashed large numbers of heavily pregnant females even before cycle 3 began. They easily resisted the 14.8 g/ha dosage (16).

The second theory was that whereas in the 1982–1983 spraying campaigns two concentrations of 30 percent emulsifiable concentrate (EC) and 20 percent EC had been applied, in 1984 30 percent was used throughout, bar a few drums of old 20 percent stock sprayed in cycle 3. The effect of the dosage reduction was that the number of droplets that might drift through *mhesvi* habitats also decreased. At the time, the role of the spray cloud's physical structure in spray effectiveness was not yet understood, but authorities speculated that smaller droplets in sufficient numbers were "the most lethal component of the spray cloud" (Allsopp and Hursey 1986, 16).

The third theory was that failure was not to be assessed just at cycle 3, but for the entire combined ground and air operation. The ground sprayers had failed to rid their assigned tactical area of responsibility of *mhesvi* and consequently to protect the aerially sprayed area from reinvasion. It was thus impossible to tell whether the old females in sprayed areas were survivors or invaders. Precedent had shown the river-hugging *mhesvirupani* to travel much further and more rapidly than previously believed. In other words, the problem did not lie with the aerial spraying itself; ground spraying seemed "too slow for it to be entirely effective in this role" (Allsopp and Hursey 1986, 16).

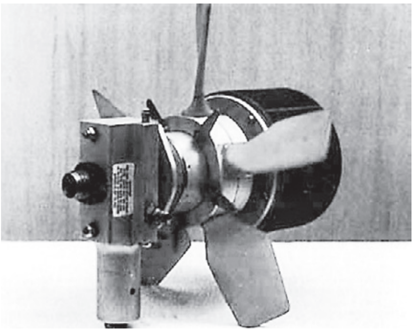
The fourth hypothesis was the meteorological effect—that is, the presence or absence of specific wind conditions determined the effectiveness of the spray. At a mean wind speed of 2 m/s, 20–30 micrometer (μm) droplets usually traveled between three and nine kilometers downwind, so the wind carried the aerosol sideways into the hidden sides and undersides of trees, logs, rocks, and leaves. With weaker or zero wind speed, the droplets fell vertically, thus leaving *mhesvi* resting under leaves and logs or in bark and rock crevices untouched (Allsopp and Hursey 1986, 17).

By 1985, a low-density *mhesvi* population was building in the northern section of the area sprayed the previous year, growing much heavier to the east, between Sebungwe and Omay. Rather than simply targeting these residual populations, the combined operation sought to eradicate dense *mhesvi* buildup in a much larger area of the Matusadonha Game Reserve extending into the strip between the Sengwa River (west) and Siakobvu.

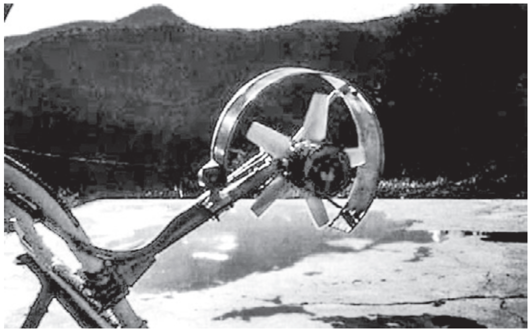
The purpose of the aerial spraying was to establish why the technique had failed in areas like Siakobvu—albeit without jeopardizing the campaign, which was generally a success.

The operations started in late July with two Cessna 401s and were conducted exactly as in 1984—with two twin-engine Cessna 401s flying in formation, starting at six in the evening and ending at six in the morning during moonlit nights, restricted to three early evening and one early morning sorties. Then, for selective treatment in difficult terrain—especially the Sengwa and Umi escarpment—the Jet Ranger was deployed. The Jet Ranger and Bell 47 were also deployed to position and service the warning beacons on dangerous obstructions like hills (see figure 11.3). However, they were fitted with the latest Micronair AU 4000 rotary atomizers, which still had the cage diameter of the original AU 3000 (i.e., six inches) (see figure 11.4a, b) but were shorter and faster. The *mushonga* used was endosulfan at 30 percent for cycles 1 and 2, reduced to 20 percent thereafter.[35] In other words, the modification of the spraying technique was an experiment to assess the capability of fixed-wing *ndege* for spraying to treat "stubborn" *mhesvi* presence. The high-density *mhesvi* population was concentrated in mopane

Figure 11.3
Chikopokopo: A Bell 47 positioning a beacon prior to spraying.
Source: Allsopp 1990.



a)



b)

Figure 11.4a, b
Unmounted Micronair AU 4000 (left), and mounted Micronair AU 4000 (right), with a metal or fiberglass shroud to protect the fuselage in case the blades break during flight.
Source: Allsopp 1990.

woodland in flat to undulating terrain—a perfect testing ground for the fixed-wing technique (Allsopp and Hursey 1986, 17).

To test this hypothesis, two adjacent blocks totaling 1,700 km^2 were chosen. One block overlapped the eastern half of the area sprayed the previous year, including the Sengwa River (reinvaded after treatment) and the Siakobvu area (never completely eradicated). To be certain that no distortions to results occurred due to carried *mhesvi*, *vatema* were stationed as "deflying pickets" on roads leading into Siakobvu.

For all the care put into the operation, it still failed to eliminate the *chipukanana* from Siakobvu. The old females apprehended all over the aerially sprayed area had clearly survived the misty bombardment. The theories put forward in 1984 to explain the failure to completely eradicate the pest were now confirmed under experiment to be false—bar one: namely, that the absence of wind or breeze had reduced the droplet efficiency, a conclusion that triggered the start of "wind tunnel studies" in the United Kingdom, which later confirmed this theory to be a fact (Johnstone 1985; Johnstone, Cooper, and Dobson 1987; Johnstone et al. 1988). To make aerial spraying more effective, the meteorological parameters needed to be well understood and the spraying technique adapted accordingly. Night spraying was now to be limited to continuously flat terrain and selective spraying to daytime and to deep river valleys and high escarpments only (Allsopp and Hursey 1986, 33).

There were positives, however. The Cessna 401 was a far superior bird than the aging Aztecs deployed in 1982 and 1983. The spray equipment had been vastly upgraded, with external custom-built tanks and well-secured and efficient Micronair AU 4000 atomizers. Not even one was lost during operations, compared to 1982. The navigation equipment and metering systems had also improved, as had loading, refueling, and servicing procedures (Allsopp and Hursey 1986, 34).

East of Matusadonha, the BTTC, in partnership with the Wellcome Research Laboratory (UK), was conducting a small trial with deltamethrin in the farming areas of Rushinga—specifically, the Chesa small-scale commercial-farming area. *Mhesvirutondo* literally had come to pasture in these farms. The planes used the Rushinga airstrip as an operational base. The sorties began on July 19 and terminated on October 1, using thiodan (endosulfan) applied in five cycles at dosages of 22, 18, 14, 14, and 14 g/ha. Except for the winds that delayed cycle 5 by four and half days, the weather could not have been better. In the end, the results were good, and barring a few holdouts thereafter (which were swiftly cleared) the operation was declared a success.[36]

Wellcome Research Laboratories also conducted another trial in a *mhesvirutondo*-infested bush straddling the Mudzi River near Nyamapanda, funded by the European Economic Community (EEC). Its objective was to determine whether deltamethrin might be a substitute for endosulfan.[37]

The 1987 operation was designed to identify a large, continuous, flat to gently undulating area for aerial spraying using fixed-wing *ndege*—the Cessna 401. Because hills could not be moved aside, they were marked with flares throughout the operation. The target of the spray was a 4,700 km^2 block between the Mozambique border and the Muzarabani-Mukumbura-Chiswiti-eastern Dande area. The Cessnas took off from Rushinga airstrip; the ground control center was at the foot of the escarpment by Musengezi River. Thiodan was the preferred choice of pesticide in five cycles in successive dosages of 22, 20, 16, 14, and 14 g/ha. This was a night-only operation, spraying five cycles from July 13 to September 19, and the weather conditions were generally conducive, allowing a westerly drift of *mushonga* droplets beyond the Manyame River. The *mhesvirutondo* population was wiped out, but the *mhesvirupani* remained even after a sixth cycle was applied. The verdict was that these *zvipukanana* had survived the aerial spray.[38] BTTC then undertook a follow-up operation to remove this residual population—without instant success, even though the *zvipukanana* died out a few months later. No *mhesvi* was captured until August 1988, and then only as the result of reinvasion from Mozambique.

The 1988 operation, also with Cessna 401s, had two aims. The first was to clear *mhesvirutondo* and *mhesvirupani* from a 2,000 km^2 area north of the Zambezi escarpment between the Angwa and Manyame drainages, composed of western Dande and parts of the Dande and Chewore safari areas. Second, the operation was also an experiment to ascertain the effectiveness and environmental effects of deltamethrin as a possible alternative to endosulfan in aerial-spraying operations. The contractor was supposed to use *ndege* capable of taking off from and landing at Mashumbi Pools. Such planes were not available, so the airstrip had to be upgraded to suit the *ndege* available.

The night operations began on June 30 and finished on September 4, having deposited five cycles of pesticide layers at 0.25 g/ha throughout. The weather was good, but still air made for suboptimal conditions in the north and center of the block; consequently, the drift was poor, reducing the effectiveness of the spray. Meanwhile, deltamethrin proved a “highly effective” pesticide against the heavy *mhesvirutondo* concentration; total eradication was achieved. However, as with endosulfan the previous year, the proposed substitute was far less effective against *mhesvirupani*—99 percent at best. As impressive as such a kill rate was, that 1 percent remaining necessitated future retreatment—a negative mark from an economic point of view. *The verdict:* Deltamethrin was neither better nor worse than endosulfan. It could be used in future operations.[39]

The Bell 206 Jet Ranger II

By 1980, *chikopokopo* the helicopter had become a popular instrument for discriminate treatment of *mhesvi* in continuous thickets, riverine forest, and tough-to-reach places. This was not by design; as one researcher noted in 1977, “the choice of a particular technique has been determined to a large extent by the nature of the habitat and the topography of the land” (Lee 1977, 6).

The Bell 206 Jet Ranger (see figure 11.5) was first deployed in *mhesvi* operations in the 1984 campaign in Chizarira, but only in a complementary role to *ndege*. From 1989 to 1990, it was put on trial as the principal sprayer. The *chikopokopo* was a two-bladed, single- or twin-engine craft, made at Bell’s Mirabel plant in Quebec, Canada, but it started its life as the Bell YOH-4, intended as a light observation *chikopokopo* for the US Army, which did not adopt it. The company redesigned it as the Bell 206A Jet Ranger, which the US Army then accepted and turned into the OH-58 Kiowa.

Figure 11.5
A Bell Jet Ranger spraying in hilly terrain.
Source: Allsopp 1990.

Several models and generations of the Bell *chikopokopo* were used in a residual spraying role throughout Africa's *mhesvi* flashpoints. For example, in Lambwe Valley, Kenya, in 1968, the Bell 47G was used effectively to apply invert emulsions (oil-based mud) (Le Roux and Platt 1968). A Bell G4A was deployed to spray DDT, dieldrin, and HCH in Niger in 1969 (Spielberger and Abdurrahim 1971). In Zimbabwe's case, the Bell 206 was available, not the Bell 47G.

The site of the spray in 1989 was a block of 126 km^2 at Shamrock Mine in Hurungwe. The Bell Ranger was equipped with two Micronair AU 4000 atomizers spraying 30 percent thiodan surplus from previous operations. This concentration was maintained throughout the spraying to enable the *chikopokopo* to lift the required volume while minimizing the number of sorties. To distinguish the droplets for experimental records, hostasol yellow 3G was added to the pesticide. The maximum safe amount of 280 liters (twenty shy of the absolute maximum) for the pesticide payload was preferred to ensure safe climbing up and away from the Shamrock Mine loading bay. This translated to 260 liters usable load and twenty remaining in the spray gear system; at the rate of 24 g/ha, that amounted to 31.5 km^2 per sortie. The Bell Ranger had no sophisticated navigation equipment like the Doppler or the SGP 500 attached, so the pilot and co-pilot navigated from maps and first reconnoitered and then followed recognizable ground features, like hills, rivers, and roads. In addition, a line marker was placed at 250-meter intervals along the line separating the block into two; from there, a marker party used flares to direct the *zvikopokopo*. The percentage of total flying hours dedicated specifically to spraying was 43 percent, compared to 44 to 94 percent for fixed-wing *ndege*; this "efficiency" would have been 50 percent if the time needed to deploy and maintain the *chikopokopo* in operation was excluded from flying time. At 11 km^2 per hour, the number of square kilometers treated per hour was far inferior to the 28.72 km^2 per hour achieved during the 1988 operation (Allsopp 1991, 23).

Effectiveness of aerial spraying remained elusive. The physicochemical monitoring showed good droplet size and distribution. The litmus test of the *chikopokopo*'s utility as a technology of spraying depended on whether there was good aerosol penetration and distribution in different terrains compared to fixed-wing *ndege*. The valley floor droplets were significantly fewer than those on hillsides and ridges; still, the ridges and hillsides were exposed and undulating, and more maneuverable with a *chikopokopo* than a *ndege*. The results in practice were overwhelmingly in favor of the *chikopokopo*: 1,500 to 1,800 droplets/cm^2 versus 276 droplets/cm^2. The explanation was not difficult to determine: *Ndege* had to maintain a safe height of between 150 and 1,000 feet over such delicate areas, whereas *chikopokopo* simply followed the terrain and rarely climbed above 300 feet. The use of *zvikopokopo* (plural of *chikopokopo*) in rugged terrain had been confirmed to be "a viable technique"; to maintain an accurate flight path without sophisticated navigational equipment was all the more impressive. With satellite navigation, ground support would no longer be necessary (Allsopp 1991, 24).

Conclusion

This chapter illustrated the interesting link between *ndege* and OCPs above with *mhesvi* below. It has shown that this was no straightforward transfer of ready-made means and ways—that is, of *ndege* and *zvikopokopo* from Europe or the United States—straight into combat against *mhesvi* in the sense of *kupa* (giving) or *kupihwa* (receiving) proven means and ways. On the contrary, aerial spraying was a site of experimentation contingent upon the very specific vegetation preferences and habitat of *mhesvi*, the geophysical nature of such habitat, and the climatic mobilities (temperature, humidity, wind speed) and seasons amenable to it. The procedures and techniques of spraying vegetation inhabited by *mhesvi* were developed through experiment in the field; that alone constitutes the spray area as a site of knowledge production. We are here, as its analysts, because of *mhesvi*, which by its presence and inevitably pestiferous mobilities forced *hurumende* to deploy this untried, expensive machinery on an experimental basis, the work of which we now write about.

The production of knowledge and standardization of the spraying modus operandi was an incremental process of informed trial and error, contributing to a more sophisticated and dynamic one. This is the re-Africanizing power of this chapter: to say that *vachena*'s knowledge and means and ways were not Houdini acts or well thought out and stable from the beginning. Instead, like *vanhu vatema*, *vachena*'s methods started from shaky premises, often on a trial-and-error basis, *until they justified themselves in practice*. This mobility of knowledge from a shaky to a stable place is the story of Rhodesia: When we set aside the morally repugnant racism and oppression, the one important lesson to be learned from the Rhodesia project (1890–1980) in Zimbabwean history is that of its creative resilience. Planes that were otherwise conventionally designed for military or passenger-carrier purposes were retrofitted into *weapon vehicles*—part transport, part weapon, transporting and bombing *mhesvi* with deadly chemicals in one move. The airspace became a test site for trying out new things and perfecting existing ones—be they *ndege*, *zvikopokopo*, spraying nozzles, chemical solutions and their strengths, or manipulations of terrain and wind conditions to achieve optimal results.

Still, the resilience of *mhesvi* shines through the treetops, as if pointing a mocking finger at the *ndege* up above. The *chipukanana* invades from adjacent areas and hatches from its shell after the spray is complete; timing and strict surveillance of the *chipukanana* and its organic vehicles becomes key. Success only has one measure: when *mafrayi* go out with a black ox and no *mhesvi* mobilities are detected.

Here, over the remote borderland forests, *ndege* deposits clouds of aerosol that land on anything below: *zvipukanana*, vegetation (including fruits growing thereon), rivers, and even people. Far from their sites of manufacture, these planes have become the face of *vachena*'s superiority over *dirt* for some, mass polluters of the environment for others.