Chapter Three

LESSONS ON DECEPTION FROM ANIMAL BIOLOGY

OVERVIEW: DRAWING LESSONS FROM NATURE

> [I]t is no exaggeration to say that the modification of outward appearance by visual characteristics, directed towards a seeing public, and serving either to facilitate recognition or to frustrate it, has been one of the main results attained in the evolution of higher animals; and such characteristics comprise some of the most outstanding examples of adaptation in the whole field of biology. (Cott, 1966)

Within a particular patch of woodland, swamp, desert, or ocean, it is common to find dozens or even hundreds of examples of deception that vary widely in form and effectiveness. The clouded leopard seen in Figure 1 (see following page 32) illustrates one of many forms of camouflage coloration.

There are countless examples of camouflage, disruptive coloration, disguises, feints and demonstrations, feigned retreats, false or misleading communications, and so on. In nature, deception is ubiquitous, overwhelmingly diverse, and spanning the length of the fossil record (Lamont, 1967, 1969; Eldredge, 1980; Thulborn, 1994; Kacha and Petr, 1995).

Previous work by the authors has detailed the relationship between deception and the urban environment (Gerwehr and Glenn, 2000) and the trouble it can present to friendly forces in urban operations; with this new effort we hope to begin the journey from diagnosing the problem to prescribing the solution. As described in that previous work, the authors reaped a bounty of insights on deception and counterdeception by delving into the experimental biological literature. We specifically wish to examine these biology-based insights as hypotheses in the context of urban operations for two reasons stemming from that previous research:

- The authors detect a potent synergy between urban operations and deception. The combatant who takes to urban ground as a means of blunting his opponent's sword while sharpening his own is very likely to see deception techniques as a whetstone, if not another weapon altogether.
- The urban environment, with its dense infrastructure and diverse resources, nourishes innovation (read: adaptation) more than any other operating environment. In the case of deception, the authors contend that the urban environment can support a number and breadth of possible ruses vastly greater than in any other operating environment (for example, consider the myriad deceptive uses to which a common desktop PC and printer might be put: creating forged documents, doctoring video, sending phony e-mail, etc.).

APPLYING INSIGHTS FROM BIOLOGY TO URBAN OPERATIONS

> [It] may well be a labyrinth, but it is a labyrinth forged by men, a labyrinth destined to be deciphered by men. (J.L. Borges, *Tlon, Uqbar, Orbis Tertius*)

When studying the methods by which animals and plants employ deception to attack, escape, discover, or attract, we have continually found ourselves asking: *Do the principles that govern deception use in nature apply to deception use in military conflict?* Moreover, *will identifying and applying these principles in a military setting be valuable?*

We have derived from the principles of animal and plant deception a set of insights and hypotheses that might be applied on the urban battlefield. Our goal was to accomplish both prescriptive and analytic ends: first, where we see the possibility for useful capabilities and methods that are not already in our arsenals, we map from animal biology into the military domain; second, when we wish to gain a useful analytic perspective on existing capabilities and methods, we map from the military domain into animal biology. To simply illustrate these two applications of theory:

- Since animals frequently use deception to gain valuable intelligence, that principle should at least be explored for military purposes. Some birds of prey screech in a manner that suggests they are swooping in for a kill (when they are doing nothing of the sort), and this often has the effect of causing hidden prey to break cover and run for their lives. Is there any *a priori* reason why unmanned aerial vehicles (UAVs) or precision-guided munitions (PGMs) couldn't accomplish something similar? Or at a higher level of war, consider the exercise preceding BLUE SPOON (later renamed JUST CAUSE): U.S. forces learned a great deal about the readiness, organization, and likely responses of the Panamanian Defense Forces (PDF) merely by watching them react to the U.S. exercise (McConnell, 1991; Donnelly, Roth, and Baker 1991). While the authors do not suggest that the exercise was a deception, future exercises could be (and might be designed with quite specific manipulative ends in mind). Judging from the applications of deception in the animal kingdom, a demonstration with the goal of gathering intelligence on the PDF would be an entirely apt use of deception.
- Modifications to synthetic aperture radar (SAR) which allow for improved acquisition of targets *concealed* by debris or foliage do not automatically yield improved discrimination of *decoy* versus real targets. In fact, there may actually be a penalty incurred in the latter task when acquisition sensitivity increases! Consider the case of seabirds hunting the flat periwinkle *Littorina obtusata* (a marine snail) on North Atlantic beaches. Research has demonstrated that seabirds form detailed "search images" of their prey to spot periwinkles camouflaged against bladder wracks (a type of seaweed) (Owen, 1980). This search image is a very specific template of objects and characteristics looked for when hunting, and by using this template the seabirds optimize their foraging for hidden periwinkles. Yet periwinkles are highly polymorphic, and many individual periwinkles are colored in a fashion entirely unlike the version in the birds' search image; they don't blend in, but rather stand out. To the predatory seabirds, they are well-hidden in plain sight, for the seabirds' strategy of spotting periwinkles camouflaged against bladder

wracks actually *interferes* with their ability to see these conspicuous ones. The specifications are too narrow, and what doesn't match the template is discarded. This finding is echoed elsewhere in experimental animal biology, such as the work of Pietrewicz and Kamil (1981), and it reasonably suggests that modifications to SAR which tighten the specifications in order to raise the signal/noise ratio or reduce the time of analysis might be counterproductive relative to other needs.

So how do these exercises in theory help us operate better in the urban environment? Consider the principles illustrated in the seabird-versus-periwinkle example as applied to targeting adversary vehicles in a city. When friendly forces demonstrate the capability to detect, identify, and destroy adversary armored personnel carriers (APCs), an adaptive adversary will resort to vehicles and traffic patterns that break with the "search image" in use by friendly targeteers. This might mean using civilian vehicles, disguising military vehicles to look like civilian vehicles, or employing military vehicles in unusual ways (such as on civilian roadways, at civilian speeds, surrounded by noncombatants, etc.). This is very much an evolutionary model: the selective pressure of improved targeting results in advantageous adaptation (deception) by the surviving targets and their "offspring," and this process cycles over the course of a campaign in what is termed "coevolution" (Slatkin and Maynard Smith, 1979; Dawkins and Krebs, 1979).

IS MILITARY DECEPTION LIKE ANIMAL DECEPTION?

> A blow to the head is the most effective way of killing an animal and many predators make their initial strike at the prey's head. Many butterflies in the family Lycaenidae have false heads at the tips of their hindwings well away from their true heads. The impression of a head is given by antennae-like extensions on the tip of the hindwings. These are moved up and down after the butterfly has alighted in the way that an insect's antennae often are, while the real antennae are kept still. (Owen, 1980)

> [I]n addition to hiding tactical assets, camouflage paint patterns can also be used to create certain tactical advantages. An example of this can be seen on Canadian CF-18 aircraft that carry a "false

> cockpit" on the bottom—a confusing illusion that could give the pilot a fractional second advantage in some dogfight situations. (*Jane's Defence Weekly,* September 2000)

Does the word "deception" mean the same thing when describing animals as when describing military actions? Let us examine the definition of deception from the joint military literature:

> Those actions executed to deliberately mislead **relevant** decision-makers as to friendly military capabilities, intentions, and operations, thereby causing the **relevant decisionmaker** to take specific actions that will contribute to the accomplishment of the friendly mission. *(Joint Publication 3-58: Joint Doctrine for Military Deception;* amended in bold by authors in Gerwehr and Glenn, 2000)

The phrase "actions executed" is sweeping: this could refer to the production and manipulation of physical objects such as false maps, misleading behaviors such as feints, or any combination of the two. The phrase "deliberately mislead" indicates that deceiving is a purposeful action taken by one party to affect another party (the "relevant decisionmaker"); deception as defined here is neither inadvertent nor self-inflicted. The phrase "friendly military capabilities, intentions, or operations" is meant to encompass the entire spectrum of target perceptions salient to the conflict: who the combatants are, what they are doing, how and why they are doing it, where they are going and when, and so on. Finally, the joint definition points out that deception is rarely conducted for its own sake: the aim of deception is to create an advantage for the deceiver. Chart 1 illustrates the joint definition of deception.

A well-developed definition for deception in animal biology (from Mitchell, 1986) is actually quite similar upon close scrutiny:

1. An organism R registers something Y from organism S, where S can be described as benefiting when
2. R acts appropriately toward Y, because
3. Y means X to R, and
4. It is untrue that X is the case.

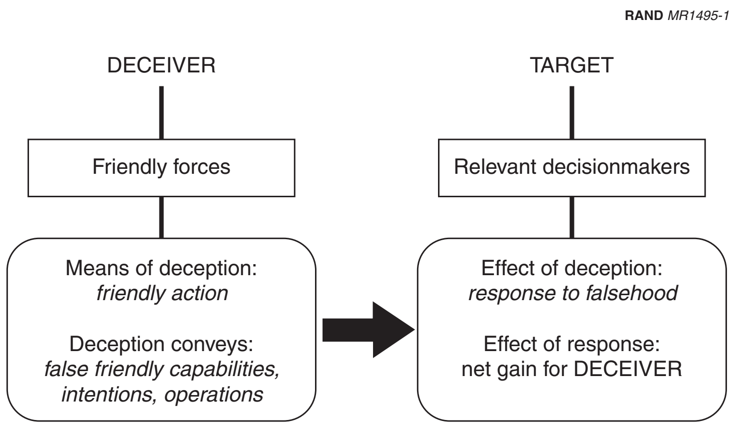

Chart 1—Deception: The Joint Definition

Simply put, the deceiver (S) employs some means (Y) against the target (R) that makes him think something false (X), which leads the target to make a mistake that the deceiver benefits by. To illustrate: The European nightjar bird (S) feigns injury (Y) to the fox (R) that is seeking the nightjar's nest, making the fox think the nightjar is an easy meal (X), whereupon the fox leaves off hunting for the nest and pursues the nightjar. After leading the fox away from the nest site, the nightjar flies away and the fox loses both bird and nest.

The term "registers" in the definition simply refers to an individual R perceiving and attending to relevant stimuli, meaning that there need not be thinking or deliberation on either side of the equation, only the transmission and reception of information. The Y term is the animal/plant equivalent to "actions executed" in the joint definition above: individual S may do, make, or employ anything Y such that R perceives and attends to it and it is relevant. The relevancy is built in by the necessity that R acts in a particular way upon receiving the transmission and S benefits by this reaction. The X term (the meaning R assigns to Y) is the equivalent of the joint definition's "friendly capabilities, intentions, and operations" and is false. Chart 2 illustrates this definition of deception used in animal biology.

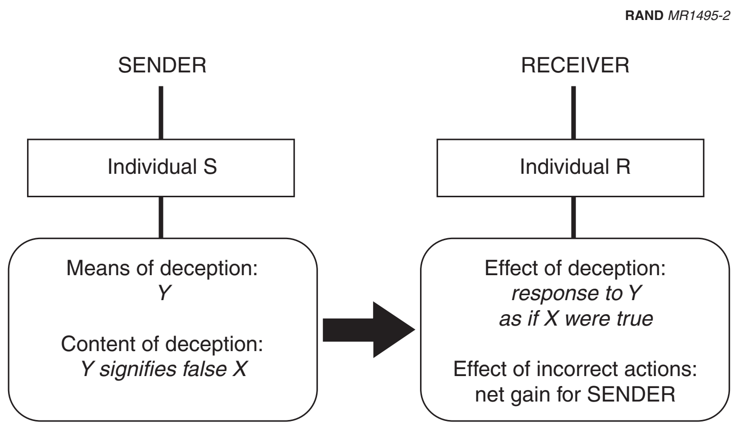

Chart 2—Deception: The Biological Definition

Although the literature on deception in animal biology has only recently emerged from naturalism and become an experimental science, it is richer and more scientifically rigorous than the corresponding literature on military deception. This should not be taken as a criticism of the quality of exposition on military deception, but rather a statement of its nature: there is relatively little *scientific* literature on military deception. What experimental work exists is often narrowly focused, and the remainder of the literature is made up of informed opinion and illustrative anecdote. Accordingly, the authors have sought to mine animal biology for suggestive lessons and experimental hypotheses on deception and counterdeception. This immediately raises an important question: To what extent is the camouflage of a spider, shark, or hawk *comparable* to the camouflage of a soldier's battle dress uniform (BDU), tank, or fighter plane? To what extent is the dangling lure of the angler fish (*Lophius piscatorius*) similar to the mannequin propped up by a Serb sniper to draw fire from enemy snipers? And we might legitimately ask the same question of the diversions, disguises, and other deception techniques seen in nature. The precise answer is unclear, but the authors hope that the following "lessons" demonstrate that animal deception and military deception are provocatively close in their methods and objectives (and by extension, in how they can be countered).

USEFUL INSIGHTS FROM ANIMAL DECEPTION

We have chosen the following three "lessons learned" because they are "unsolved" problems: that is, these are areas that the U.S. armed forces are working to improve. Moreover, they are of particular relevance to the urban environment, and we intend to provoke discussion and debate on the active motion camouflage, multiple modes of deception used in concert, and subversion/infiltration, all as applied to urban operations. While the authors do not claim that problems have been solved in all their complexity within the experimental literature of biology, we do suggest that valuable practices and observations may be gained from looking therein.

Lesson 1: Masking Signature While in Motion

> **Camouflage**: The use of natural or artificial material on personnel, objects, or tactical positions with the aim of confusing, misleading, or evading the enemy. (Joint Pub 1-02)

> Usually, the optic flow [on the surface of the retina] produced by a moving object is inconsistent with that produced by a stationary one. Evidently, the visual systems of many animals are capable of detecting this inconsistency, but this poses the question: how can one animal (or agent) track, or "shadow" another without giving itself away by its own motion . . . to [the authors'] knowledge, the problem of active motion camouflage has not been considered previously. (Srinivasan and Davey, 1995)

The utility of camouflage is very widely appreciated (Cott, 1966; Hartcup, 1979; Stanley, 1998; Owen, 1980). The rattlesnake in Figure 2 (see following page 32) demonstrates the effectiveness of camouflage coloration/patterning when matched well with the environment. From the infantryman to the joint force commander, every combatant recognizes that effective camouflage and concealment figures prominently in the formulae for survival and success. This enduring element of warfighting is just as visible in the tactics of 12th-century Saracens (Dewar, 1989) as it is in the tactics of 21st-century Serbs (U.S. Air Force Headquarters, 2000). Yet, as mentioned previously, numerous questions remain unanswered about the exact utility, parameters, variability, and longevity of camouflage. One need but look at the literature of animal biology to begin finding promising approaches to acquire those answers. Questions posed experimentally of nonhuman species that employ camouflage are strikingly similar to the questions we pose here: How much camouflage (termed crypsis in biology) is enough to provide useful protection (Pietrewicz and Kamil, 1981)? How much is too much (i.e., wasted effort)? How long can camouflage be expected to last (Dawkins, 1971)? How does its value vary over the course of time and through a series of hostile encounters? The authors believe that these experiments and outcomes can serve as initial experimental hypotheses for testing in military settings. Consider the value of such studies, as represented by answering just a few of these questions:

- Is it worth expending resources to protect a force with "masking" camouflage if the force must frequently move? Could other force-protective measures (deceptive or not) be more apt?
- When advancing on an enemy position, how exactly should a camouflaged force be moving relative to potential observers? What should their gait be? Their angle of approach? Their speed?
- What does the curve of expected returns look like when a moving force deviates from optimizing its camouflage? We might expect a precipitous drop-off, but will that depend on *how* they are deviating or on the mere fact of deviance? Can any or all concealment value be recovered? How?

Let us focus on one key question: What happens to the value of a masking camouflage scheme when the deceiver moves? Note that to begin this discussion we deliberately choose camouflage aimed at producing a "masking" effect as opposed to "confusing" or "misleading" effects. Traditionally, this common type of camouflage is seen as valuable only when it is applied to a motionless target. As far as the authors know, there is no research on the topic of what happens to the camouflage of a tank, or truck, or soldier when in motion. Presumably its value lessens, but by how much? The authors have seen little research in the military domain that investigates such questions as

- How much camouflage masking value *(v)* is lost given increases of motion *(m)* in terrain of type *(t)*, etc.?

- Are there types of motion, or angles of movement relative to observers, or rates of speed that preserve some of the value of camouflage? Which preserve the value and by how much?
- How does the environmental context affect the value and preservation effect?
- Can the value of the camouflage be preserved by employing additional measures (colored smoke, environmental effects, ambient noise, diversions/distractions, etc.)?
- Should camouflage be designed in part for stillness and in part for motion?

and so on. As we shall discuss (see Table 1, page 30), there are a great many valuable questions about deception that are at present unanswered. The authors believe that these additional questions about camouflage and motion may be seen as *representative* of the kinds of detailed knowledge that U.S. forces should be actively seeking. It is certainly critical that experiments and exercises be conducted to directly address the issue for military purposes. The literature of animal biology is a valuable resource in this regard: we may mine it for useful questions as well as a suggestive array of answers.

If we have made the case that the literature of animal biology/deception can provoke questions, what about putative answers? If camouflage is less valuable when the subject is moving, what stratagems are animals employing to preserve or supplant that value? Consider three examples of species that have tackled the reducing-signature-while-in-motion problem in decidedly different ways. All seek an initial masking effect but with varying objectives, means, and outcome spaces.

- **Zone-tailed hawk (*Buteo albonatus*).** This predator hides in plain sight, as it were. It glides along within a group of vultures—commingling—using their presence as a mask to its own. Rodents upon which these hawks prey ignore vultures (which do not attack them); the presence of vultures in close proximity acts to reduce the signature of the hawk until it breaks from the group and swoops in for the kill. In this case, the camouflage is "designed" for motion and lasts right up until the hawk makes its attack. (Brown and Amadon, 1968)

- **Hoverfly (*Syritta pipiens*).** As male hoverflies seek a mate, they engage in a shadowing behavior that appears to preserve their camouflage. As the female moves, "the male yaws and moves laterally in such a way that it always stays on a line connecting the shadowee to the [stationary reference point]" (Srinivasan and Davey, 1995). In so doing, the image it produces upon the retina of the female remains unchanging, lending it the appearance of remaining itself stationary. This likely preserves the full value of whatever camouflage it has even while in motion, and it will last for as long as the male can maintain the appearance of immobility on the retina of the female. Note that this example from biology is consonant with our revised definition of deception: the target of the deception is not an "adversary decisionmaker," but rather a "relevant decisionmaker."
- **Okapi (*Okapia johnstoni*).** This grazer (pictured in Figure 3; see following page 32) has very typical camouflage coloration and countershading to reduce or prevent acquisition by predators. Its camouflage is decidedly less valuable as it moves, so the okapi "freezes" when danger threatens in order to acutely increase the potency of its camouflage pattern. However, natural selection has apparently decreed this to be insufficient deception given the predators in its environment, and thus the okapi has disruptive leg and hindquarters markings that seek not to mask but to confuse predators while in motion. It would therefore seem reasonable to characterize this camouflage pattern as relatively weak in motion but with a "surge" capability (the freezing behavior) and an overall short-lived viability as suggested by the disruptive marking contingency measure.

Clearly, there are many ways to skin the proverbial cat. Concealment while on the move might be gained through a number of methods; the examples noted above represent only a tiny fraction of the diverse means by which animals have addressed the problem. Who might benefit from looking more deeply into this topic? The authors believe that this is a lesson with wide applicability. Snipers and small units clearly could make use of anything that would improve their chances of remaining unobserved as they move from building to building, room to room. The intelligence provided by tactical UAVs might be multiplied considerably if they can flit about undetected. Vehicles that would come under fire when advancing down a thoroughfare in a column might be able to concentrate unmolested if they gather obliquely, from dispersal. The possibilities are many; the value added may be considerable. Parenthetically, the reverse side of the coin is equally valuable in each of the aforementioned cases: understanding how active motion camouflage is *defeated* in the animal kingdom is just as valuable a lesson for military purposes. Friendly forces would profit from improvements in their capabilities to acquire gunmen hidden among crowds and the like.

Lesson 2: Nesting Deceptions

> [E]ven a single individual may use several deceptive and defensive tricks when confronted by a predator, just as a predator may use several different ways of finding and overcoming its prey. (Owen, 1980)

A recurring motif in animals that employ deception is the concept of "nesting," or employing more than one type of deception to thwart foes (whether on offense or defense). It is noteworthy that natural selection, which is quite unforgiving of wasted effort, has produced more than one manifestation of deception in a single species, and many, many species nest deceptions. Moreover, these nested deceptions tend to be of different types. For example, it is common for species with camouflage (a masking effect) to also have a decoy structure or behavior (a misdirecting effect). Thus gecko lizards often have attractive, disposable tails in addition to camouflage; or the okapi mentioned in the section above has countershading plus disruptive hindquarters markings; or the angler fish *Lophius piscatorius* is marvelously camouflaged against the sea bottom yet also employs a worm-like lure to draw in potential prey.

Consider three examples of species that employ nested deceptions to great advantage. All three combine distinctly different deceptions within one individual.

- **Sepiola.** This squid's deceptions work most effectively *in concert*. When a predator approaches, the squid emits a cloud of ink between itself and the advancing foe. This ink cloud is shaped and colored roughly like the squid itself, presenting an attractive target. Yet rather than just allow the predator to choose between two likely targets, the squid changes color and darts away from the predator, lowering its own apparent value as a target.

- **Caterpillar of *Cerura vinula* moth.** This creature demonstrates the kitchen-sink approach to nesting deceptions. The caterpillar is camouflaged to mask its signature among the leaves where it feeds, and it also has a purplish-brown midsection that breaks up its outline. If spotted and approached, it inflates a neck color that sports two threatening eyespots in an attempt to appear like something bigger and frightening. This enlarging effect is also supported by its arching body, and the attempt at intimidation is supported by its lashing red tail. Parenthetically, the caterpillar also regurgitates an acrid-smelling goo, possesses a tenacious grip on its perch that is very difficult to dislodge, and has a slippery, hard patch behind its head (a likely strike spot for a predator). The deceptions do not *need* to work together or even with the caterpillar's other defenses; any one can succeed for a defensive victory.
- **European grayling (Hipparchia semele).** This butterfly's deceptions are staged temporally. Upon alighting, the butterfly flashes its forewings, which are adorned with eyespots to startle and flush out potential predators (the eyespots are also a likely strike point for predators). If a predator is present, the butterfly either flies away successfully or gets a bite taken out of the nonessential forewings. If there is no predator, the forewings are folded and the camouflaged hindwings are unfurled to cover the creature. It then leans over to eliminate shadow and hides out. The temporal aspect of this whole scheme is key, because the deceptions would be much less effective in any other sequence but are tremendously effective in actual practice.

What are the analogs in military operations, and why do they matter? The combination of camouflage plus decoys proved to be a vexing problem for NATO air power in Kosovo, and that difficulty would be magnified considerably were those same air strikes to be conducted in urban population centers. Or consider the wide range of Chechen deception measures employed against the Russians in the battle for Grozny: the combination of diversions plus disguises, or disinformation plus demonstration, or camouflage plus commingling with noncombatants. We would hypothesize that as the animal kingdom seems to demonstrate, the *combination* of deception measures can be synergistic. Furthermore, given the authors' earlier research (Gerwehr and Glenn, 2000), it seems likely that *combined or nested deceptions within the urban environment are more potent still*.

What does studying deception nesting in the animal kingdom provide for those considering deception in urban operations?

- First of all, it seems readily apparent that if one is conducting deception in the urban environment, employing multiple forms of deception can be worth the investment. Adversaries all too often rely upon one form of sensor or sensory analysis, and it is altogether unlikely that a single sensor will pierce two or more morphologically/behaviorally distinct deceptions. Put another way, *nesting deceptions usually trumps a single mode of counterdeception*. Moreover, even if a foe has two forms of reconnaissance—helicopters and ground troops, for example—it is in the nature of urban terrain to hamper intelligence and communications, not to mention making a very unwelcome venue for aviation assets. The city hinders counterdeception of many sorts (particularly those that are technologically based and those of the "outsider" or foreign force). *Confusion, ambiguous intelligence, and a high OPTEMPO—hallmarks of urban operations—are ideal deception facilitators*.
- Second, the reverse is true: more than one mode of perception must be employed, which is likely to be well worth the investment. Had Operation Allied Force adhered to applicable ground-force doctrine instead of relying exclusively upon airborne assets, the authors deem it highly likely that the effectiveness of Serb camouflage and decoy targets would have been significantly reduced if not negated. Why? Because the features of camouflage or decoys that deceive the eye at three or four miles altitude are less effective against the eye on the ground. Making camouflage or decoys equally useful against both sets of observers requires more time, more resources, and more skill. The burden upon the deceiver is therefore much greater and the execution that much more difficult.

Lesson 3: Infiltrating and Subverting

> **Infiltration**: 1. The movement through or into hostile territory occupied by either friendly or enemy troops or organizations. The movement is made, either by small groups or by individuals, at extended or irregular intervals. When used in connection with the enemy, it infers that contact is avoided. 2. In intelligence usage, placing an agent or other person in a target area in hostile territory. Usually involves crossing a frontier or other guarded line. Methods of infiltration are: black (clandestine); grey (through legal crossing point but under false documentation); white (legal).
> (Joint Pub 1-02)

> In deceiving the enemy as to his methods and intentions the guerrilla will use many ruses . . . *[He must have] agents working among the civilian population*. (*Handbook for Volunteers of the Irish Republican Army,* 1956 edition, emphasis added)

Urban zones are often densely populated with noncombatants, and among the most intractable of challenges in urban operations is the task of acquiring, identifying, engaging, and neutralizing adversary elements while they circulate among that civilian populace. Combatants with links to the local population in an urban conflict enjoy a tremendous advantage in intelligence gathering; communications networks; freedom of movement; anonymity and concealment; and availability of food, fuel, ammunition, medical treatment, and other vital resources. Combatants who are perceived as foreign bodies (or worse yet, *hostile* foreign bodies) in the corpus of the city suffer the opposite set of consequences: their senses are dulled; their communications are degraded or made more fragile; their actions are clumsy and exposed; and their logistics and resupply are more difficult. Given the disparity between these two states, it is an obvious priority for individual or small-unit urban operators to develop effective techniques for penetrating, co-opting, and installing themselves in population centers. Numerous historical examples shed light on how this might be accomplished on a large scale; useful insights may be gained from individuals' memoirs of the Provisional Irish Republican Army (PIRA) in Ireland, Irgun in Palestine, Front de Libération Nationale (FLN) in Algeria, Tamil Tigers in Sri Lanka, Hezbollah in Lebanon, Baader-Meinhof in West Germany, Chechens in Grozny, Tupamaros in Uruguay, Red Brigades in Italy, and so on.

However, the vast majority of this documentation takes the form of anecdote or informed opinion: it is useful and interesting, but not leavened to the status of testable hypotheses on infiltration and subversion.

The authors suggest that, akin to the preceding discussion of camouflage, many aspects of infiltration remain unbounded, unquantified, and therefore not fully understood. The following list represents just a few important questions on this topic for which there are currently no experimentally derived answers:

- What is the right number of individuals to attempt grey infiltration in a given scenario? Should one agent at a time be inserted, or is there strength in numbers?
- Is appearance more or less convincing than manner? Is false paperwork more or less persuasive than a seamless contextual facilitator (e.g., the target's expectations of time, place, and action are met)? How do these elements interact synergistically to create a more or less convincing deception?
- How much is black infiltration aided by masking? By misdirection? By confusion?
- What is the relationship of time to infiltration? How rapidly and at what rate should attempts be made?
- How much does desensitization (i.e., "crying wolf") help infiltration attempts? How much does disinformation (e.g., false news reports) help?

Clearly, many more such questions may be asked and experiments can and should be conducted in the military domain to arrive at answers. However, the authors are once again struck by the analogy between infiltration as seen in biology (from viruses to vertebrates) and the phenomenon as it is described above. We are not answering these questions here; instead we are proposing that biology represents a useful source of insight and method. The biological literature is replete with examples of species that infiltrate others' nests or territory to predate, escape predation, scavenge more easily, or otherwise gain advantage. Consider four examples of such species.

- **Rove beetle (*Atemeles*).** This beetle demonstrates the power of deceptive communication. It looks nothing like an ant, nor does its larva. However, the beetle's secretions calm aggressive ants and then stimulate adoptive behavior from them. Once carried into the nest, the beetle lays its eggs and the hatching larva emit a third secretion, which forces receiving ants to feed them (Holldobler, 1971). The key ingredient to this infiltration scheme is the overriding power of ant communication methods. When a seemingly legitimate order is received, the order is obeyed regardless of the unusual nature of the request. In human terms, this might be seen as exploiting high degrees of automation: passwords are among the most anemic of security systems, yet they remain among the principal means of safeguarding information systems and communications.
- **Cuckoo bird (*Cuculus canorus*).** These parasites specialize: individual female cuckoos select nests of a particular host and, when the parent is away, lay an egg of approximately the same coloration as the host's (Figure 4; see following page 32). Thus a reed-warbler specialist lays greenish, spotted eggs, whereas a redstart specialist lays pure blue eggs. The infiltration is "fire-and-forget": once the subversive egg is laid (which takes mere seconds), the female cuckoo abandons it completely. The deception relies upon the inflexible machinery of the host bird's rearing behaviors. If an egg of approximately the right form hatches in the nest, what emerges must be reared. This form of deception entirely relies on precise, prior intelligence of the target; there is no fine-tuning after the ruse is begun.
- **Marine fluke (*Monogean trematode*).** These marine parasites offer an alternative to the cuckoo model of parasitism. When these organisms attach themselves to a target fish, they draw tissue samples from the specific portion of the target to which they are anchored. They then use this material to render themselves of a texture and color that matches the location. When mutualist organisms that clean the parasites from hosts come along, the flukes are left unmolested as they appear to be part of the host. This model of infiltration might therefore be considered both more flexible and more risky than the cuckoo's. There is a wider target range (the attachment of the fluke can take place in a

variety of locales on the host), but more investment and time are required.

- **Wasp mimics.** Certainly not all infiltration attempts are for offensive ends; a wide variety of insects (and spiders) mimic the common *Vespula* wasp and live alongside it. The wasp's reputation for delivering a nasty sting is well known, allowing other species that might otherwise be easy pickings for local predators to operate with some impunity. The key to this form of infiltration is using deception (mimicry) to resemble a very specific and respected member of the community whose status allows for freedoms not given to other residents. Relating this to the human realm, one immediately thinks of assuming the identity of a Red Cross worker, journalist for a well-known news organization, or cleric as opposed to just another disenfranchised citizen.

As suggested by the preceding examples, infiltration can come in a variety of forms: parasitic, where the intruder battens off of the host population without intending to kill it, or predatory, where the intruder gains ingress and sets about attempting to eradicate (consume) the host population. When the PIRA intimidates or metes out punishments (e.g., kneecapping) to the Irish Catholic population, it is assuming a parasitic role (the victims and witnesses are deliberately left alive to capitulate). On the other hand, when operatives of Hamas or the Liberation Tigers of Tamil Elam (LTTE) engage in a suicide bombing, their goal is the destruction or removal of their adversaries. Why point out this difference? Because the measures U.S. forces might take to rid a population of a parasite are necessarily different from those taken to combat a predator.