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Potential Value of Plants as Sources of New Antifertility Agents I *

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Keyphrases □ Antifertility agents—review of plant sources, classified by anatomical mechanism and folkloric route of administration □ Medicinal plants—sources of antifertility agents, classified by anatomical mechanism and folkloric route of administration, review □ Plant extracts—potential sources of antifertility agents, review □ Contraceptives—plants with active constituents, review □ *Abortifacients*—plants with active constituents, review □ Oxytocics—plants with active constituents, review □ Estrogenic plants—review of active principles

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The world population explosion has pointed out the need for new and effective contraceptive agents and/or methods, having a minimum of side effects and giving a maximum protective effect. To date, the most effective and widely used contraceptives have been steroids, but these are not without side effects (1, 2).

Practically all major research to date involved with the search for new oral contraceptives has been of the synthetic type, particularly the preparation of steroid derivatives. Very little attention has been directed to the plant kingdom. There are those who continue to argue that plant products are of little importance as drugs. However, an analysis of some 1.05 billion new and refilled prescriptions dispensed from community pharmacies during 1967 showed that 25% contained one or more active principles derived from higher plants (3). Only three of the higher plant products (papaverine, ephedrine–pseudoephedrine, and caffeine) are produced commercially by synthesis, the remainder still being produced by extraction from

plants. Practically every pharmacological category of drug has as its prototype a substance of natural origin; thus it is not unreasonable to believe that the plant kingdom should yield an effective antifertility drug.

The problem underlying the search for natural antifertility drugs basically concerns deciding which of the approximately 750,000 species of higher plants should be examined in an animal system for their potential antifertility effects. There appear to be only three paths to follow, *i.e.*, *(a)* test plants that have folkloric reputation as having been used by primitive women as oral contraceptives, *(b)* test plants that are known to contain constituents that theoretically could affect the female cycle to produce antifertility effects (estrogenic sterols, coumestrols, and isoflavones) or that have a potential to contract the uterus, and *(c)* make a random collection–mass screening of all available plants for antifertility effects. The first two of these methods appear to be the most practical and realistic.

The tables in this article list those plants that have a folkloric reputation as having been used as oral contraceptives or that have been tested for antifertility effects in animals but may or may not have shown activity. We hope to point out that even though certain plants have been tested in animals for antifertility effects, the negative results presented may or may not be valid. Different species can vary in their response to different types of compounds. Furthermore, the antifertility tests used have not always been designed to test for all types of antifertility effects; that is, by using a too restricted dosing period (giving the extract only prior to mating or for only a few days after mating), for example, antifertility effects produced by some mechanisms will be identified but not those produced by others.

Because of the importance of the selection of the proper biological test to detect antifertility effects in plant extracts, the various mechanisms whereby compounds can exert an antifertility effect in various common laboratory animal species will also be reviewed.

ANTIFERTILITY MECHANISMS IN LABORATORY ANIMALS

Reproductive Cycles of Commonly Used Laboratory Species—There are a number of areas within the female mammal where substances having antifertility effects may exert their action(s); these areas are the hypothalamus, anterior pituitary, ovary, oviduct, uterus (including the endometrium, myometrium, and cervix), and vagina. A given compound may exert its antifertility effects in more than one of these areas and not necessarily by the same pharmacological mechanism. Conversely, different compounds may act in the same area to inhibit fertility but in some cases by different mechanisms.

Much information concerning the mechanisms by which chemicals may inhibit fertility has been obtained from studies carried out in commonly used laboratory species such as the rat, mouse, hamster, guinea pig, and rabbit. The reproductive cycles of these species differ among themselves as well as from those of the human and other primates. Such differences can explain, in part, the varying effects sometimes exhibited by a given antifertility substance when tested in different speeies; *i.e.*, antifertility agents interrupt reproductive function at some point, and if endogenous control at this point varies among species, different results with a given compound are possible. Consequently, and also since an understanding of antifertility mechanisms requires an understanding of reproductive function, a brief comparison of the latter in the commonly studied species will be made first. Additional comparisons among species will be made where pertinent during discussion of specific antifertility mechanisms.

Table I summarizes the major similarities and differences in the reproductive cycle function among the rat, mouse, hamster, guinea pig, and rabbit; the first four species are spontaneous ovulators, and the fifth is a coitus-induced ovulator. Schwartz (4) recently compared the ovulation-controlling systems in these two types of ovulators. In spontaneous ovulators, folliculotrophic hormone (follicle-stimulating hormone and luteinizing hormone) stimulates ovarian follicles to grow and secrete estrogen, the latter serving as a feedback signal to the hypothalamic–pituitary axis that follicles have matured. The estrogen acts with an environmental facilitating signal, *e.g.*, the time of day, to induce the ovulatory surge of luteinizing hormone. The latter also causes progesterone secretion which, in turn, acting on a background of estrogen, causes mating behavior. In induced ovulators, folliculotrophin also stimulates follicle growth and estrogen secretion. However, besides signaling the hypothalamic–pituitary axis that follicles have become ovulable, the estrogen, centrally, also induces mating behavior and hypothalamic sensitivity to feedback from coital stimulation. The latter triggers the luteinizing hormone surge which, in turn, causes progesterone secretion and ovulation.

As can be seen in Table I, complex hormonal interrelationships are involved also in the induction and maintenance of pregnancy.

Antifertility Mechanisms Classified by Anatomical Site Involved—The disruption and/or desynchronization of integrated preovulatory and preimplantational events are the means by which many kinds of compounds can impair fertility. A discussion of the mechanisms involved follows. Antifertility mechanisms involving other stages (*e.g.*, postimplantational) of the reproductive cycle also will be considered. The mechanisms will be presented according to the site in the animal at which the antifertility action is exerted.

Hypothalamus–Pituitary—These two areas are considered together for two reasons. First of all, functioning of the pituitary is under intimate control of the hypothalamus by means of hormone-specific releasing factors, *e.g.*, follicle-stimulating hormone and luteinizing hormone releasing factors (10). Secondly, the question as to whether certain substances might act on the hypothalamus and/or on the pituitary has been controversial. While steroids, for example, may exert some effect directly on the pituitary (10), evidence suggests that their major site of antifertility action is in the hypothalamus (8). Other drugs appear to act in the brain *outside* the hypothalamus; *i.e.*, certain central nervous system (CNS) depressants and autonomic blocking agents apparently block neural pathways to the hypothalamus (8, 10).

Therefore, two basic mechanisms can be considered: *(a)* disruption of the normal humoral and hormonal functions of the hypothalamus and/or pituitary, respectively, by steroids, by nonsteroidal agents (*e.g.*, methallibure[1]) having antigonadotrophic activity, and by steroid antagonists (8); and *(b)* disruption of neural input to the hypothalamus, *e.g.*, from the environment (10) and from the postulated "clock" that controls the release of gonadotrophin-releasing factor(s) in spontaneous ovulators (8).

With respect to *(a)*, antigonadotrophic activity of estrogenic steroids can be demonstrated, for example, by their ability to block compensatory hypertrophy of the remaining ovary in unilaterally ovariectomized rats (11); in women, decreased follicle-stimulating hormone excretion can be measured during usage of contraceptive doses of estrogens (12). Progestagens in women (11, 12) and presumably also in laboratory animals (13) are able to inhibit the ovulatory surge of luteinizing hormone.

Demonstrating both ovulation-inhibiting *and* antifertility effects of estrogens and progestagens in laboratory animals could present a problem, however, since spontaneous ovulators may become coitus-induced ovulators under certain circumstances (4). The occurrence of such a phenomenon could explain the less than

[1] 1-α-Methylallylthiocarbamoyl-2-methylthiocarbamoylhydrazine (ICI 33,828).

Table I—Comparison of Reproductive Cycles of Five Laboratory Species[a]

Species	Ovulation	Nonmated Cycle Length, days	Luteal Phase[b]	Luteolysis	Hormonal Requirements for Mating Behavior	Pseudopregnancy		Implantation		Pregnancy			
						Length, days	Hormonal Requirements	Day[c]	Hormonal Requirements	Endocrine Gland Requirements[d]			
										Length, days	Anterior Pituitary	Ovary	Hormonal Requirements[e]
Rat	Spontaneous	4, 5	Ps	Nonpregnant uterus[f]	Estrogen and progesterone	12–14	Estrogen, prolactin	5–6	Progesterone and estrogen	22	12	20–21	Prolactin, follicle-stimulating hormone, and luteinizing hormone
Mouse	Spontaneous	4, 5, 6	Ps	Nonpregnant uterus[f]	Estrogen and progesterone	10–12	Prolactin	4–5	Progesterone and estrogen	19–20	11–12	18–19	Prolactin; luteinizing hormone after implantation
Hamster	Spontaneous	4	Ps	Nonpregnant uterus[f]; luteinizing hormone[g]; estrogen (by inhibiting follicle-stimulating hormone)	Estrogen and progesterone	8–10	Prolactin, follicle-stimulating hormone, and luteinizing hormone	4	Progesterone	16	16	16	Prolactin, follicle-stimulating hormone, and luteinizing hormone
Guinea pig	Spontaneous	15–18	S	Nonpregnant uterus[f]; estrogen (mediated by uterus)	Estrogen and progesterone	—	—	6–7	None	67–71	3	20	None, providing viable fetuses are present *in utero*
Rabbit	Coitus induced	Relatively continuous estrus[h]	SPs	Nonpregnant uterus[f]; luteinizing hormone[g]	Estrogen	17	Estrogen	7–8	Estrogen is unnecessary	32	32	32	Estrogen, to maintain the progesterone-secreting corpora lutea

[a] Data presented taken from Refs. 4–9. [b] Ps = pseudopregnancy; functional corpora lutea found following sterile mating or cervical stimulation. S = spontaneous. SPs = in the rabbit, the luteal phase occurs spontaneously following ovulation, but ovulation must be induced, *e.g.*, by sterile mating. [c] Day 1 of pregnancy is the morning on which a copulation plug and/or sperm in the vagina are found. [d] Days of pregnancy through which endocrine glands must be present for pregnancy to be maintained; removal is compatible with pregnancy if and when the placenta can assume the role. [e] In the absence of the anterior pituitary. In the rat, the replacement therapy indicated stimulates both estrogen and progesterone secretion. In the mouse, luteinizing hormone sustains estrogen secretion. The conceptus in all five species secretes a luteotrophic hormone to varying degrees. [f] The luteolytic factor produced by the endometrium is believed to be a prostaglandin, probably $PGF_{2\alpha}$. [g] High doses of luteinizing hormone are luteolytic in these species. [h] There are seasonal variations in mating behavior and responsiveness to other ovulation-inducing procedures.

100% inhibition of ovulation produced by a norethynodrel–mestranol combination in rats (14). Nevertheless, the achievement of satisfactory contraception in women, in the absence of consistent inhibition of ovulation by contraceptive steroids (12), implies that additional antifertility mechanisms may be at work. The latter possibility is of special significance since it has been suggested that external stimuli may also be able to induce women to ovulate (8).

Nonsteroidal antigonadotrophic agents and steroid antagonists may present even further difficulties with respect to the demonstration of ovulation-inhibiting *and* antifertility (*before* fertilization) effects. As shown in Table I, estrogen and progesterone are necessary for normal mating behavior in the spontaneous ovulators, while estrogen is necessary for such behavior in coitus-induced ovulators such as the rabbit. Compounds given chronically to inhibit gonadotrophin secretion directly would indirectly inhibit ovarian secretion; if such compounds themselves had no estrogenic and/or progestagenic activity, animals treated with them possibly might not mate. Furthermore, estrogen antagonists such as 1-(*p*-diethylaminoethoxyphenyl)-1-phenyl-2-*p*-methoxyphenylethanol[2] and *trans*-1-(*p*-α-dimethylaminoethoxyphenyl)-1,2-diphenylbut-1-ene[3], which apparently block the estrogen feedback on the hypothalamus that is necessary for the ovulatory surge of luteinizing hormone, also can block mating behavior, at least in the rat (15, 16).

With respect to *(b)*, since the hypothalamus is subject to neural input from other areas of the brain, substances having CNS depressant activity and/or effects on neurohumoral transmission could be expected to alter gonadotrophin secretion. Pentobarbital, morphine, and atropine have been shown to block the ovulatory surge of luteinizing hormone in laboratory animals, apparently by elevating an arousal threshold in the midbrain reticular formation (17). Tranquilizers such as reserpine and chlorpromazine, anesthetics such as ether (diethyl) and halothane, and adrenergic (as well as cholinergic) blocking agents also have been shown to exert inhibitory effects (directly or indirectly) on the hypothalamus (8, 10, 18, 19). The antifertility usefulness of drugs having such effects is questionable, partly because of their other pharmacological effects but also because it has been shown that rats, at least, have sometimes become coitus-induced ovulators following blockade of their gonadotrophin surge by pentobarbital or chlorpromazine (4).

It is apparent from Table I that interference with gonadotrophin secretion may have postovulatory antifertility effects. The secretion of estrogen and/or progesterone needed for implantation in some species is under pituitary control. Luteal function also remains directly under pituitary control for half the length of pregnancy in the rat and mouse and for the entire duration of pregnancy in the hamster; it remains indirectly under pituitary control throughout pregnancy in the rabbit since *estrogen* is the ultimate luteotrophin in this species (5).

In contrast, in the guinea pig, the pituitary is unnecessary after the 3rd day of pregnancy (5); and hypophysectomized women, caused to ovulate by the sequential administration of follicle-stimulating hormone and human chorionic gonadotrophin, have become pregnant without further gonadotrophin replacement therapy (20). It is not surprising, therefore, that ergocornine, which has been shown to inhibit prolactin secretion in rats (21), has also been shown to inhibit progesterone secretion in pseudopregnant rats (22) and to interrupt pregnancy in rats (23), the latter two effects presumably mediated by the former. Ergocornine did not interrupt pregnancy in rabbits (12) or guinea pigs (13) nor interfere with luteal function in nonpregnant women (24).

Ovary—Substances having antifertility properties may exert their effects at the ovarian level by inhibiting ovulation and/or steroidogenesis. Although the actual intraovarian mechanisms causing ovulation are still unclear, it appears that protein synthesis may be involved; actinomycin D, which inhibits DNA-dependent RNA synthesis, has been shown to block pregnant mare serum gonadotrophin- and human chorionic gonadotrophin-induced ovulation in hamsters (25).

Although the mechanism(s) involved have not been elucidated, the results of work by other investigators suggest that phenoxybenzamine (26), an α-adrenergic blocking drug, and CNS depressant drugs, particularly reserpine (8), may inhibit spontaneous and pregnant mare serum gonadotrophin–human chorionic gonadotrophin-induced ovulation, respectively, by acting directly on the ovary. Experimental evidence suggests that contraceptive steroids also may act directly on the ovary to inhibit ovulation and/or some aspect of steroidogenesis (12).

Steroidogenesis, itself, may be involved in the process of ovulation. 2α-Cyano-4,4,17α-trimethylandrost-5-en-17β-ol-3-one (cyanoketone), a compound that inhibits the conversion of Δ^5-pregnenolone to progesterone, of 17α-hydroxypregnenolone to 17α-hydroxyprogesterone, and of dehydroepiandrosterone to Δ^4-androstenedione, has been shown to inhibit ovulation, possibly by interfering with steroidogenesis in the ovary (27).

As can be deduced from Table I, steroidogenesis is important for the induction and/or maintenance of pregnancy. The specific requirements vary among species, however; in the hamster and guinea pig, estrogen actually is luteolytic. The steroidogenic function of the ovaries is taken over by the placenta or the fetoplacental unit in the guinea pig by Day 20 of pregnancy (5), in the monkey by Day 25 (20), and in the human by Day 41 (28). Drugs having a direct inhibitory effect on ovarian steroidogenesis, particularly on luteal function, have the potential for interrupting pregnancy in the latter three organisms if given early enough and in the rat, mouse, hamster, and rabbit if given at any time during pregnancy. Depending on the species considered, estrogens and prostaglandins are two such classes of compounds.

As already indicated, estrogen is luteolytic in the hamster and guinea pig (Table I). In the monkey, estrogen administration early in the luteal phase has been shown to decrease progesterone secretion and to hasten the onset of menstruation (20); similar effects have been produced by estrogens in women (20, 29). The lowering of postovulatory plasma progesterone levels may be at least one mechanism by which postcoitally administered high dose estrogen exerts its antifertility effect in women (29). In contrast, in species such as the rabbit and rat in which estrogen is needed for normal luteal function, estrogen antagonists such as *trans*-1-(*p*-α-dimethylaminoethoxyphenyl)-1,2-diphenylbut-1-ene are likely to interfere with luteal function (30).

Prostaglandins can interrupt pregnancy in many species, but the mechanisms of action are still unclear (31); in some cases, the actions are at site(s) other than in the ovary *(vide infra)*. Administration of $PGF_{2\alpha}$ has been shown to shorten the lifespan of the corpus luteum and/or to decrease the ovarian secretion of progesterone in the rat, hamster, guinea pig, rabbit, mouse, and sheep (32); in the primate, however, effects of prostaglandins on corpus luteum function have been inconsistent (31). Even in the rat (31) and rabbit (33), susceptibility of the corpora lutea to the luteolytic effects of $PGF_{2\alpha}$ varies with the stage of pregnancy.

All species in which prostaglandins have been shown to be luteolytic are those in which the uterus influences the lifespan of the corpus luteum. The uterus in these species apparently secretes a luteolytic factor which is believed to be a prostaglandin(s) (31). In the guinea pig, hamster, and rat, at least, the endogenous luteolytic effect has been shown to be produced locally (5).

Oviduct—Since normal implantation depends on the correct timing of the arrival of the blastocyst in the uterus, disturbances of tubal transport may be accompanied by failure of implantation (8). Substances having the ability to alter oviductal motility may thereby be able to inhibit fertility. However, although ovarian hormones have been shown to influence the motility of the human oviduct *in vitro*, what effect, if any, contraceptive steroids may have on the latter in the *in vivo* situation is unknown (12). It is possible, however, that postcoitally administered, high dose estrogen may act in part by this means in the human (29, 34). The effects of some other substances on the human oviduct *in vivo* have been studied. For example, PGE_2 has been shown to inhibit tubal motility whereas $PGF_{2\alpha}$, at the same dose, has been shown to stimulate it (35).

The oviducts of rats, rabbits, and humans possess a rich sympathetic innervation, especially in the region of the isthmus, maintaining the tone of the isthmic sphincter and causing retention of fertilized ova in the oviducts. Administration of autonomic drugs, at least to these species, can influence the rate of ovum transport, although their ability to do so may be modified by estrogens and progesterone (25).

It has long been thought that luteal progestagen regulates the

[2] MER-25, ethamoxytriphetol.
[3] ICI 46,474.

relatively slow rate of passage of preimplantation ova through the oviducts (36) and that the smooth muscle of the reproductive tract exhibits maximal contractility only under the influence of estrogens (37). Recent evidence, however, suggests that smooth muscle (at least of the rabbit oviduct) is minimally active in the presence of physiological concentrations of estrogens; that its activity increases as estrogen content decreases; and that, when it is subject to the influence of estrogen, it will become increasingly active if progestagens are introduced (37). Megestrol acetate, a progestagen without estrogenic effects (38), has been shown to accelerate ova transport in the rabbit, which mechanism might contribute in part to its antifertility effect in that species (39). Nevertheless, since both estrogens and antiestrogens have been shown to alter ova transport and simultaneously to impair fertility, it would appear that a critical balance of estrogen and progesterone may be necessary for normal postovulatory events to occur (8). However, additional postovulatory antifertility mechanisms *(vide infra)* may also be playing a role in at least some cases; this possibility should not be ruled out.

Exogenous estrogen administered to many species during early pregnancy results in rapid passage of ova through the oviducts and expulsion of the ova from the uterus (36). However, at certain dosages (36) and/or when given at very specific times (40), estrogen alternatively may cause the retention of ova in the oviducts. For example, treatment of mice with 1.6 μg of estradiol on Day 1 of pregnancy, when the ova were still in the ampulla of the oviduct, resulted in retention of the ova in the oviduct (largely in the ampulla) until Day 4, presumably due to prolonged closure of the ampulla–isthmus junction. In contrast, treatment with 0.4 μg on Day 2, when the ova already were in the isthmus of the oviduct, resulted in premature entry of the ova into the uterus and a decrease in the recovery of ova by 50% (40).

A number of compounds having estrogenic activity *(vide infra)* and representing several different chemical classes have been shown to accelerate ova transport, *e.g.*, two nitriles, 2,3-bis(4-hydroxyphenyl)valeronitrile[4] and 2,3-bis(4-methoxyphenyl)pent-2-enenitrile[5], in rats (41); dienestrol [4,4′-(diethylideneethylene)diphenol] in rats (42); and nafoxidine[6] [1-[2-[*p*-(3,4-dihydro-6-methoxy-2-phenyl-1-naphthyl)phenoxy]ethyl]pyrrolidine] in mice (8, 43).

That accelerated transport of ova results in decreased fertility is, of course, partly due simply to the expulsion of the fertilized ova from the reproductive tract (36). However, it has been shown (34) that fertilized ova degenerate when transplanted into the uterus too early; an inability of the ova to survive in the uterus apparently contributes to the impaired fertility observed following accelerated ova transport from the oviducts. The decreased fertility, however, is thought to be due to the uterine environment and not to the rapid transport *per se* (8).

Nafoxidine also has been referred to as an antiestrogen *(vide infra)*, as has a structurally related compound, 1-[2-[*p*-(3-hydro-5-methoxy-2-phenylindyl)phenoxy]ethyl]diethylamine[7] (44). It is to the antiestrogenic property of these compounds and to that of *erythro*-ethyl-α′-methyl-4,4′-dihydroxybibenzyl that the investigators attribute their findings that these three compounds can cause tube locking of ova in mice.

Tube locking of ova, of course, obviously impairs fertility by preventing the fertilized ova from getting to the uterus, the normal site for implantation. The fertility of tube-locked ova *per se* may not be impaired, however, as suggested by observations made in one study in the mouse (40). Although tubal retention of ova, induced by estradiol, was associated with delayed development of the blastocele, the ova implanted normally following transfer to vehicle-treated recipients.

That the antifertility activity of a compound such as nafoxidine has been attributed to estrogenicity of the compound in some studies (8) and to its antiestrogenic activity in others (44) may seem confusing at first, but it has been difficult to determine whether many compounds have antifertility activity by virtue of their being estrogenic, their being antiestrogenic, or their having some other property (8). Certain compounds, in fact, are antiestrogenic at lower doses and estrogenic at higher doses. Furthermore, some evidence (45) suggests that there may be species differences, at least between the rat and the hamster, with respect to whether a given compound exerts antifertility activity, estrogenic activity, and/or antiestrogenic activity, differences not entirely explicable by differences in hormonal requirements between the two species (Table I).

The estrogenicity of a compound is defined most specifically as the latter's ability to produce vaginal cornification (keratinization) in ovariectomized rats or mice (the Allen–Doisy test) (11); androgens and progestagens may produce vaginal mucification, but they are incapable of producing keratinization (46). Alternatively, investigators may employ a uterotrophic bioassay in immature and/or ovariectomized rats or mice to determine estrogenicity. This test is less specific, however, since a small degree of uterine growth can be produced by androgens and progestagens (11). The latter test does have the advantage that a dose–response curve for a given compound can be obtained more objectively (47).

Antiestrogenicity similarly may be defined as the ability of a compound to inhibit the effects of standard estrogens such as estrone (11), estriol (11), and estradiol (48) when the test compound is administered with the known estrogen in one and/or both of the tests for estrogenicity. Androgens and progestagens may show antiestrogenic activity in these tests (11); the weak plant estrogens, coumestrol and genistein, also have been shown to have inhibitory effects in such tests (49). Antiestrogenicity in an antifertility test could be manifested by the blocking of a step in the reproductive cycle that requires estrogen (Table I).

Uterus—Antifertility agents that prevent ovulation and/or fertilization commonly are referred to as contraceptive agents, whereas those that act after implantation has taken place usually are called abortifacients. The term interceptive has been used by some workers (50) to refer to compounds that act after the occurrence of fertilization but prevent implantation from taking place. By this definition, then, compounds interfering with the secretion of the proper amounts of steroids needed during this time period, whether acting directly on the ovaries or indirectly by inhibiting gonadotrophin or prolactin secretion, can be referred to as interceptives, although their earlier or later administration might render some of them contraceptive or abortifacient, respectively. Drugs altering ova transport *(vide supra)* also can be considered interceptives, as can those that destroy the fertilized ova or blastocysts and those that act on the trophoblast or uterus to prevent implantation.

Experimental designs may not always be sufficient to distinguish among these specific mechanisms for given compounds. It is quite possible, furthermore, that agents exhibiting antifertility effects when given to experimental animals during the first several days postcoitum may actually be acting in more than one of these ways. Experiments in which the test compound is administered from Days 1 to 7 of pregnancy and in which only the number of implantation sites and/or litter size is determined do not elucidate which interceptive mechanisms might be involved and/or if indeed an early abortifacient action might be involved (51, 52). With additional techniques and/or more restricted dosing periods, one or more of these effects can be identified.

Although blastocyst transfer experiments (8, 53) seem to have ruled out a direct zygotoxic effect as a possible mechanism by which a number of compounds inhibiting implantation may act, observations made in a few other studies suggest the contrary. Degenerating morulae, for example, have been found in rats treated with medroxyprogesterone acetate[8] on Day 1 of pregnancy followed by estrone on Day 3 (54), and degenerating blastocysts have been found in mice treated with ethinyl estradiol on Day 1 of pregnancy (55); tubal transport appeared to be altered in the latter study as well. Inhibited growth of blastocysts, as indicated by computed blastocyst volume, together with accelerated ova transport has been demonstrated in rabbits administered the progestagen, chlormadinone acetate, for 3 days preceding the occurrence of induced ovulation (56). A mixed copolymer of phenylmethylcyclosiloxane that was administered to rabbits on Days 4 and 5 of pregnancy subsequently was found to have been taken up by the 6-day-old trophoblasts, resulting in degenerative changes in the trophoblasts (57); there was no effect on the embryonic cells. Implanta-

[4] SC-3402.
[5] SC-3296.
[6] U-11, 100A.
[7] Triethylamine, U-11, 555A.

[8] Depo-Provera.

tion did not occur; neither did changes in the uterine cells that normally accompany implantation.

That implantation *per se* can be inhibited has been shown in a number of studies. Neuraminidase in the mouse was most effective when given on Days 4 and 6 or 5 and 7 of pregnancy, times at which ova had begun implanting or had just implanted in the controls (58). The results suggested that the compound might have interfered with the development of already implanted ova as well as with the implantation of ova. *N*-(2-Chloro-1-naphthylidene)-3-amino-2,6-lutidene was more effective in preventing implantation in rats when given on Days 3–5 of pregnancy (59), while the effectiveness of 5-[[(α,α,α-trifluoro-*m*-tolyl)oxy]methyl]-2-oxazolindinethione[9] in rats required that its administration be continued beyond Day 3 of pregnancy or be begun before Day 7 (60).

Observations reported in two studies (61, 62) suggest a centrally mediated anti-implantational effect for D-6-methyl-8-cyanomethylergoline[10], a compound structurally related to the naturally occurring alkaloid agroclavine, which has been reported to inhibit implantation in mice and rats (63). D-6-Methyl-8-cyanomethylergoline was effective in rats when given orally up to Day 7 of pregnancy (61). In mice, there was failure of implantation as well as failure of occurrence of the progesterone-influenced uterine cellular changes characteristic of Day 4 of pregnancy when D-6-methyl-8-cyanomethylergoline was given on the first 2 or 3 days of pregnancy but not when given only on Day 1 (62). Treatment on Days 6 and 7 resulted in resorption of fetuses in some mice by Day 9, whereas treatment beginning on Day 7 had no effect. D-6-Methyl-8-cyanomethylergoline probably acts by suppressing prolactin release *via* stimulation of prolactin-inhibiting factor release from the hypothalamus (61); prolactin from the pituitary apparently is necessary until Day 7 of pregnancy, at which time the placenta begins secreting a luteotrophic substance for corpora lutea maintenance (62).

It has already been pointed out *(vide supra)* that a certain hormonal balance in the internal milieu of the reproductive tract appears to be important for postovulatory events to occur normally. However, although estrogen is necessary during early pregnancy in some species (Table I), it is not necessary for implantation in the rabbit, guinea pig, and hamster; furthermore, the requirements are not known for the larger domestic animals or for the primates (8), including the human (12). Nevertheless, it appears possible that nonphysiological treatment of the endometrium with hormones may impair fertility in the human.

Klopper (64), for example, pointed out that some progestagens, such as those found in oral contraceptives, produce an asynchronism between the development of the endometrial stroma and that of the endometrial glands. He suggested that an endometrium so treated might resist implantation. On an acute treatment basis, it has been suggested (60) that an excess amount of estrogen present shortly after ovulation (in mammals) might prematurely sensitize the uterus so that the latter would be in a refractory state at the time of arrival of the blastocyst.

On the other hand, it has been suggested (65) that, by virtue of their antiestrogenic properties, compounds such as *trans*-1-(*p*-α-dimethylaminoethoxyphenyl)-1,2-diphenylbut-1-ene, 1-[2-[*p*-(3-hydro-5-methoxy-2-phenylindyl)phenoxy]ethyl]diethylamine, nafoxidine, and clomiphene prevent implantation, at least in the rat, by counteracting the estrogen needed for implantation; this estrogen is thought to be secreted on Day 4 of pregnancy. *trans*-1-(*p*-α-Dimethylaminoethoxyphenyl)-1,2-diphenylbut-1-ene appeared to be maximally effective when given on Day 4 and inactive when given on Day 5. Estriol, a so-called "impeding" estrogen, inhibited pregnancy *completely* when administered at a dose of 12.5 μg for the first 4 days of pregnancy but not when administered for only the first 3 days (66). Its presumably anti-implantational effect was inhibited when 0.05 μg of estradiol was administered on Day 4 together with the estriol (67).

Certain substances instilled locally into the uterus can impair fertility by affecting the endometrium in such a way that obstruction of the lumen occurs. Intrauterine instillation of a suspension of quinacrine in the rat, for example, induced a giant cell foreign body reaction in the endometrium and a consequent obstruction of the lumen, resulting in infertility for several months (68). Quinacrine instillation into the oviducts has been used as a nonsurgical means of inducing sterility in women (69).

Some compounds have postimplantational antifertility effects in nonprimate mammals but apparently not in the primate (70, 71). Demecolcine, for example, produced fetal death in rabbits and rats by means of a direct effect on the fetus; the placentae and implantation sites were not damaged. This compound had no effect on pregnancy in the macaque monkey. Clomiphene also was effective postimplantationally in the rabbit but again not in the macaque monkey. This drug, in contrast to demecolcine, affected the implantation site but exerted no effect on the fetus.

An abortifacient type of antifertility effect can be produced by compounds that stimulate uterine contractility. Sulman (72) suggested the latter as being the ultimate means by which monoamine oxidase inhibitors might induce abortion when injected into the human amnion. He reasoned that an inhibition of the amniotic monoamine oxidase enzyme system would result in serotonin's not being metabolized to 5-hydroxyindolylacetic acid. Therefore, serotonin would accumulate in the uterus and promote uterine contractility and eventually abortion. Monoamine oxidase inhibitors have been reported to interrupt pregnancy in several species, and intrauterine instillation of pargyline hydrochloride has been used successfully to induce abortion in the human (12).

The hormone, oxytocin, can be used close to term to induce labor but is ineffective as an abortifacient agent if used earlier in pregnancy (73). Prostaglandins, however, are now widely being used for the latter purpose. Observations made in humans (74), rabbits (74), and rats (75) suggest the following as the means by which prostaglandins induce abortion.

Prostaglandins appear to promote myometrial contractility which, in turn, generates internal shortening and stretch of the myometrial wall. As a result, cyclic intrauterine pressure is promoted which, together with vasoconstriction contracture, reduces uterine blood flow. The degree of this effect apparently is sufficient to compromise the endocrine function of the fetoplacental unit; as a result, estradiol and progesterone levels in the blood decrease. Following steroid withdrawal, the uterus, relieved from suppression, becomes converted into a spontaneously active, pharmacologically reactive organ, such as is normally seen only near term. The endogenous stimulatory mechanism at this time may be sufficient to complete the abortion; if not, additional prostaglandin or oxytocin may be used.

This hypothesis is supported indirectly by the results of another study (76). Three of nine women less than 4 weeks pregnant aborted completely following intravaginal administration of $PGF_{2\alpha}$. Only these three showed a significant fall in serum human chorionic gonadotrophin level, which was followed by a decrease in serum steroid level. Unfortunately, no measurements of uterine contractility were made.

Antifertility activity exerted at the level of the cervix (the neck of the uterus) or at the level of the vagina *(vide infra)* once more involves a discussion of prefertilization events. For example, the production of a cervical mucus that is "hostile" to sperm penetration is thought to be the major mechanism by which low dose progestagen-only contraceptives exert their antifertility effect in the human (77); it also has been suggested that progestagens in the human may inhibit further transport of the sperm that are able to reach the uterus (8). Testing for such activity in laboratory species, however, presents some difficulty. In the rat, mouse, hamster, and guinea pig, sperm are deposited in the uterine horns immediately after copulation (78). The rabbit, however, may be used as a model for investigating substances for contraceptive activity based on inhibition of sperm transport through the cervix; in this species, the ejaculate is deposited merely deeply within the vagina. One study did indeed show that relatively few sperm reached the anterior uterus and oviduct in rabbits pretreated for 7 days with progesterone, as compared with the number of sperm reaching these sites in the oil-treated controls (79).

Vagina—Spermicidal preparations, of course, are available for local application within the vagina. Their mechanisms of action are not well understood, and the effectiveness of many is poor (80). The five preparations that appear to have the highest rate of use effectiveness all contain polyethoxy derivatives, and four of the five contain compounds derived from phenoxypolyethoxyethanol. The results of recent experiments suggest that the effectiveness of

[9] U-11,634.
[10] 6605 VUFB, CME.

vaginal contraceptives might be able to be improved by means of the incorporation of an acrosin inhibitor into the preparation.

Acrosin is a proteolytic enzyme extractable from sperm acrosomes and is essential for penetration of the zona pellucida of the ovum by the spermatozoon during the process of fertilization (81). This trypsin-like protease has been found in sperm from a number of species: dog, rabbit, ram, bull, monkey, man, rooster (82), boar, stallion, guinea pig, hamster, and rat (83). Ejaculated sperm tend to have lower acrosin activity than do epididymal sperm, apparently due to adsorption by the sperm of an inhibitor substance present in the seminal plasma (83). This natural inhibitor is removed from the sperm during their residence in the female reproductive tract (84). Other substances that inhibit human and boar acrosin include trypsin–plasmin inhibitor bdellin B-3 from leeches, trypsin inhibitor and trypsin–plasmin inhibitor from guinea pig seminal vesicles, and the pancreatic trypsin inhibitors of pig, sheep, and dog (85). Human acrosin also is inhibited by soybean trypsin inhibitor and 1-chloro-3-tosylamido-7-amino-2-heptanone (86), a synthetic proteinase inhibitor that forms an irreversible complex with acrosin (84). Rabbit acrosin is inhibited by lima bean trypsin inhibitor, ovomucoid (87), diisopropylfluorophosphate, 1-chloro-3-tosylamido-7-amino-2-heptanone, and soybean trypsin inhibitor (81).

Of greater significance is that a number of these acrosin inhibitors have been shown to inhibit fertilization. Crystalline ovomucoid and soybean trypsin inhibitors inhibited the *in vitro* fertilization of rabbit ova by capacitated rabbit sperm (87), capacitation being defined as the physiological and biochemical change that allows for penetration and fertilization of ova (88). *In vivo* fertilization of rabbit ova was inhibited by rabbit seminal plasma trypsin inhibitor and pancreatic trypsin inhibitor, following placement into rabbits' oviducts of capacitated sperm treated with one of these inhibitors (89). *In vivo* fertilization of hen ova also was decreased in birds inseminated with rooster sperm that had been incubated with 1-chloro-3-tosylamido-7-amino-2-heptanone (82). Inhibition of fertilization following intravaginal deposition of synthetic trypsin inhibitors also has been reported (81).

This discussion has been an attempt to outline the mechanisms by which compounds having antifertility properties may exert their effects; it has been noted that different effects may be seen in different species. Only a small number of compounds showing antifertility effects have been indicated. Additional examples (predominantly synthetic compounds) can be found in Refs. 8, 10–12, 17, 34, 36–38, 44–50, 59–61, 64, 65, 68, 70, 71, and 80.

CONTRACEPTIVE AND INTERCEPTIVE PLANTS

The review of the literature in this and subsequent sections has included plants having folkloric reputations as well as those extracts shown to be active in animals or humans as antifertility agents, abortifacients, uterine stimulants, estrogenic agents, or cytotoxic agents (as applied only to antifertility effects). The search of the literature extends through 1973. Sources of references included *Chemical Abstracts, Biological Abstracts, Index Medicus,* and *Pharmacognosy Titles.*

Folkloric references can be obtained by an intensive study of ancient herbals and/or books on medical botany or by referral to review articles for which others have supposedly gleaned the older literature. Most folkloric references were obtained from the latter source, since a rather substantial number of articles and books have been acquired on medicinal folklore. No literature search of the medicinal folklore can ever be considered as complete, but we have done the best possible with available resources. Many references to books and articles on medicinal folklore could not be obtained by library personnel, even after exhaustive source searches. Such articles may or may not have contained information pertinent to the current effort.

In this section, we shall refer only to plants that have a folkloric reputation as preventing conception or that have been tested in animals or humans for the ability to prevent conception. Conception is being defined here as the successful implantation of a blastocyst in the uterine lining. Plants owing their activity to an estrogenic effect will be considered later in this review. Abortifacients and cytotoxic agents will not be considered in this section, since they do not prevent conception.

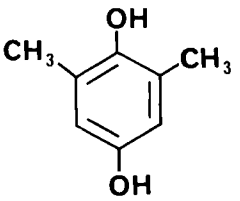
The most helpful references to plants alleged to have contraceptive (and/or interceptive) properties were the reviews of de Laszlo and Henshaw (90), Malhi and Trivedi (91), and Brondegaard (92). Many articles were encountered in which the titles implied that contraceptive plants were to be considered; however, the major thrust of such articles was an enumeration of folkloric abortifacient and/or emmenagogue plants. These will be considered in a subsequent section.

A total of 225 species of plants was found to be used as folkloric contraceptives and/or interceptives. These plants are classified into 181 genera and 76 plant families. The names of these plants, together with other pertinent data, are presented in Table II.

Another source of information on contraceptive and/or interceptive plants was a compilation of papers from the current literature in which, for one reason or another, certain plants were screened for their antifertility effects in laboratory animals. The names of these plants, together with other data such as the plant part used, the type of solvent used for preparing the extract to be tested, the test animal, and comments relative to the results, are presented in Table III. There are 145 species of plants tabulated in Table III, and these are classified into 132 genera and 57 families.

Active Contraceptive Agents—Only a few purified active antifertility principles from higher plants have been isolated. A brief summary will be made concerning each of these principles.

m-*Xylohydroquinone*—In his review of studies leading up to the isolation of *m*-xylohydroquinone (I), Sanyal (174) indicated that a study involving the vitamin contents of different cereals in India had led to the observation that male and female rats fed on a restricted diet consisting entirely of "matar" or peas *(Pisum sativum)* did not produce offspring. Sanyal (143) also cited a study in which litter production in mice was decreased when the animals were fed *P. sativum* at a level of 20% in the diet; litter production was completely abolished when the level was raised to 30%. He noted that the population of Tibet had remained stationary for the previous 200 years and, coincidentally, that the staple diet of the Tibetians consisted of barley and peas.



I: *m*-xylohydroquinone

The active principle of peas was finally isolated from pea oil and characterized as I (174). The compound produced fetal resorption in pregnant rats when given during the first 8 or 10 days of pregnancy but had no effect when given later. Further observations in rats suggested that I might be acting as a vitamin E antagonist.

Sanyal (174) cited a clinical trial of I. The pregnancy rate in Indian women was reduced by about one-half in those receiving this compound as compared with those receiving a placebo. Compound I appeared to be nontoxic in women treated twice monthly with 150–300- (147) or 300–350- (146) mg doses.

Price (175), without citing references, more recently reported that later workers had not been able to substantiate the earlier claims for the antifertility effects of I.

Lithospermic Acid—One of the most intriguing of the antifertility plants is *Lithospermum ruderale.* It was first used by the Navajo Indians as a contraceptive, as reported in 1941 (97). This plant is an herb indigenous to some of the Rocky Mountain states and is commonly known as "stoneweed." In 1945, Cranston (176) reported that when this plant was fed to adult female mice with previously regular estrous cycles, the mice developed prolonged periods of diestrus. This finding was confirmed later (177, 178). In 1949, Cranston and Robinson (179) demonstrated that extracts of *L. ruderale* decreased the gonadotrophic activity of the pituitary glands of adult female mice without producing irreversible or histological damage to the pituitary. In 1952, Kleber and Gisvold (180) confirmed that anestrus was produced in mice fed *L. ruderale,* but a phytochemical study failed to yield active principles.

Plunkett *et al.* (181) and Plunkett and Noble (182) studied the effects of *Lithospermum* extracts on rats and demonstrated that:

Table II—Folkloric Antifertility Plants

Plant Name	Part[a]	Method of Use	Country	Reference
Aizoaceae				
Trianthema pentandra[b]	—	—	India	192
Trianthema portulacastrum[b]	—	—	India	192
Amaranthaceae				
Achyranthes aspera[b]	—	—	India	192
Amaranthus spinosus[b]	—	—	India	171
Amaryllidaceae				
Stenomesson variegatum	—	—	South America	92
Anacardiaceae				
Rhus trilobata	LF	Decoction is drunk	United States	92
Semecarpus anacardium	RT	Root is cooked in sour rice water; taken for 3 days at end of menstruation; produces sterility	India	90, 192
Semecarpus stellata	RT	Decoction is drunk in sour rice mucilage	India	92
Annonaceae				
Annona squamosa[b]	—	—	India	192
Apocynaceae				
Apocynum androsaemifolium	RT	Boiled in water and drunk once weekly	North America	90
Cerbera manghas[b]	—	—	India	171
Nerium indicum[b]	—	—	India	171
Rauvolfia serpentina[b]	—	—	India	192
Thevetia peruviana[b]	—	—	India	171
Araceae				
Acorus calamus	RT	Water decoction is drunk with milk after menstruation	India	91
Anthurium tessmannii	IF	Powdered and added to food eaten by women	Columbia	92, 93
Arisaema atrorubens	RZ	Infusion is drunk with *Asclepias syriaca*	Canada	92
Arisaema triphyllum	RT	Decoction is taken to prevent conception for 1 year	United States	90, 92
Caladium seguinium	PL	Juice is used by women to achieve temporary or permanent sterility; added to diet in prisoner-of-war camps	South America, Germany	90, 94, 95, 175
Dieffenbachia seguine	LF, ST	Chewed by both sexes	Puerto Rico, Guadeloupe, Cuba, Dominican Republic, Santa Lucia	92, 94, 95
Philodendron dyscarpium	IF	Powder is added to food eaten by women	Colombia	92, 93
Urospatha antisylleptica	SP	Powder is added to food eaten by women	Colombia	92, 93
Araliaceae				
Hedera helix	FR	Decoction of dried berries is drunk after "purification"; 1 dram causes sterility	Mediterranean	90, 92
	FL	Infusion is drunk	Iran	92
Aristolochiaceae				
Aristolochia clematitis	SD	Used to prevent conception	Hungary	90, 92
Aristolochia indica[b]	—	—	India	192
Asarum canadense	RT, RZ	Boiled slowly over a long period; decoction is drunk by women	North America	90, 92
Asclepiadaceae				
Asclepias hallii	PL	Infusion is drunk after birth	United States	90, 92
Asclepias syriaca	RT, RZ	Infusion is drunk to produce temporary sterility	Canada	90, 92
Calotropis gigantea[b]	—	—	India	192
Calotropis procera	RT	Water decoction is drunk	India	91
Marsdenia tenacissima	RT	Water decoction is drunk	India	91
Basellaceae				
Basella alba	RT	Water decoction is drunk	India	91
Berberidaceae				
Berberis aristata	EX	Water decoction is drunk	India	91, 192
Epimedium alpinum	LF, RT	Taken in wine after menstruation to prevent conception for 5 days; root causes sterility	Europe	90
Podophyllum hexandrum[b]	—	—	India	171
Betulaceae				
Betula bhojpattra	SB	Water decoction is drunk	India	91
Bignoniaceae				
Dolichandrone falcata[b]	—	—	India	192
Boraginaceae				
Cordia dichotoma	FR	Water decoction is drunk	India	91

Table II—*(Continued)*

Plant Name	Part[a]	Method of Use	Country	Reference
Cordia quarensis	RT	Chewed by young women	Africa	90
Lithospermum arvense	PL	Mixed with food	Europe	90
Lithospermum officinale	RT	Infusion of root is drunk	United States	92
Lithospermum ruderale	RT	Infusion of root is taken daily for 6 months	United States	90, 92, 97
Bromeliaceae				
Ananas comosus	FJ	Fresh juice is taken raw	Malaya	90, 192
Ananas sativa	FJ	Fresh juice is taken raw	Malaya	90
Tillandsia decomposita	FS	Decoction is drunk	South America	92
Buddlejaceae				
Buddleja asiatica	—	—	India	192
Capparidaceae				
Crataeva nurvala[b]	SB	Water decoction is drunk	India	91, 92
Caprifoliaceae				
Lonicera ciliosa	LF	Infusion is drunk	United States	92
Viburnum prunifolium	—	Hot decoction is taken before menstrual period; relieves dysmenorrhea and controls fertility	Italy	90, 92
Caricaceae				
Carica papaya[b]	—	—	India	192
Celastraceae				
Celastrus paniculatus[b]	—	—	India	192
Chenopodiaceae				
Chenopodium album	PL	Mixed with diet	Hungary	90
Salsola sp.	LF	Infusion is drunk	Algiers	92
Commelinaceae				
Aneilema conspicuum[b]	—	—	India	171
Aneilema scapiflorum[b]	—	—	India	171
Compositae				
Achillea millefolium	PL	Hot infusion is drunk or mixed with food	Europe	90
Artemisia siversiana[b]	—	—	India	171
Artemisia vulgaris[b]	—	—	India	171
Atractylis gummifera	RT	Decoction is drunk by men	Arabia	92
Bahia dissecta	RT	Boiled 30 min; drunk during menstruation; used also by men	United States	90, 92
Chrysanthemum indicum[b]	—	—	India	171, 192
Cnicus benedictus	PL	Taken as a tea	North America	90
Echinops echinatus[b]	—	—	India	171
Eupatorium odoratum	RT	Taken orally	Central America	90
Franseria artemisioides	PL	Decoction is drunk	Colombia	92
Stevia rebaudiana	LF, ST	Infusion is drunk	Paraguay	92
Tanacetum umbelliferum	—	—	India	171, 192
Convolvulaceae				
Cuscuta sp.	PL	—	United States	92
Cuscuta reflexa[b]	—	—	India	171, 192
Crassulaceae				
Crassula abyssinica	PL	Used to reestablish the menstrual cycle in case of a late period	Africa	98
Cruciferae				
Anastatica hierochuntica[b]	—	—	India	171, 192
Brassica campestris[b]	—	—	India	171
Brassica nigra	SD	Water decoction is drunk	India	91, 171
Capsella bursa-pastoris	PL	Mixed with food	Europe	90
Lepidium sativum[b]	—	—	India	171, 192
Cucurbitaceae				
Citrullus colocynthis[b]	—	—	India	171, 192
Cucumis sativus[b]	—	—	India	171
Cucumis trigonus[b]	—	—	India	171, 192
Lagenaria siceraria	FR, SD	Water decoction is drunk	India	91
Luffa acutangula[b]	—	—	India	171, 192
Luffa echinata[b]	—	—	India	171
Momordica charantia[b]	—	—	India	192
Momordica tuberosa[b]	—	—	India	192
Trichosanthes bracteata[b]	—	—	India	171
Trichosanthes cucumerina	—	—	India	171
Dioscoreaceae				
Dioscorea sativa var. *rotunda*	TU	Eaten raw without water	Australia	90
Ericaceae				
Rhododendron anthopogon[b]	—	—	India	171
Euphorbiaceae				
Croton tiglium[b]	—	—	India	171, 192
Euphorbia atoto[b]	—	—	India	171, 192
Euphorbia neriifolia	RT	Water decoction is drunk	India	91
Euphorbia resinifera[b]	—	—	India	192
Euphorbia tirucalli[b]	—	—	India	171, 192

(continued)

Table II—*(Continued)*

Plant Name	Part[a]	Method of Use	Country	Reference
Excoecaria agallocha[b]	—	—	India	192
Mallotus sp.	RT	Scrapings from root are chewed with betel and swallowed	Oceania (Buka)	90, 92
Mallotus philippinensis	FR	Water decoction is drunk	India	91
Ricinus communis	SD	Eaten 1 day after delivery	India	91
	SD	Dipped in warm blood of rabbit	Algiers	92
Gentianaceae				
Frasera speciosa	PL	Decoction; one-half cupful is taken occasionally	United States	90, 92
Gramineae				
Bambusa arundinacea	RT	Water decoction is drunk	India	91
Chusquea ramosissima	YS	Chewed	Paraguay	92
Dendrocalamus strictus[b]	—	—	India	192
Echinochloa frumentacea[b]	—	—	India	171
Guttiferae				
Garcinia morella[b]	—	—	India	192
Garcinia pedunculata[b]	—	—	India	171
Juglandaceae				
Juglans regia	LF	Infusion is drunk (with saffron)	Slovakia	92
Labiatae				
Ocimum basilicum	LF	Chewed	Gunantuna	92
Ocimum sanctum	LF	Taken orally	India	99
Origanum majorana	LF	Taken orally as a tea	Germany	90
Rosmarinus officinalis	PL	Decoction with "Ocean *Artemisia*"	Central America (Opata Indians)	92
	PL	Tea with "Ocean *Artemisia*"	Central America (Opata Indians)	90
Salvia officinalis[b]	—	—	India	192
Salvia plebeia[b]	—	—	India	192
Lauraceae				
Cinnamomum cassia[b]	—	—	India	192
Leguminosae				
Abrus precatorius	SD	Powder is eaten	India	192
Butea monosperma	FL, SD	—	India	91, 192
Cassia lanceolata[b]	—	—	India	192
Cicer arietinum[b]	—	—	India	192
Desmodium retroflexum[b]	—	—	India	192
Entada scandens	SD	Eaten raw or roasted	Australia	90, 92
Erythrina variegata var. *occidentalis*[b]	—	—	India	171, 192
Piliostigma thonningii	RT	Infusion is drunk	East Africa	92
Pisum sativum	SO	—	India	171
Prosopis algarobilla	RT	Decoction is drunk	South America	92
Rhynchosia minima[b]	—	—	India	192
Sesbania aegyptica[b]	—	—	India	91, 192
Sesbania sesban[b]	—	—	India	171
Trifolium subterraneum[b]	—	—	India	171
Uraria lagopoides[b]	—	—	India	192
Vigna phaseoloides	RT	Infusion is drunk together with root of *Piliostigma thonningii*	East Africa	92
Liliaceae				
Aloe barbadensis[b]	—	—	India	192
Asparagus acutifolia	FR	Decoction is drunk	Europe	90, 92
Asparagus officinalis	FR	Decoction is drunk	Europe	90, 92
Gloriosa superba[b]	—	—	India	192
Smilacina stellata	RT, LF	Tea from leaves; one-half cupful is drunk daily for 1 week	United States	90, 92
Veratrum californicum	RT	Decoction is drunk	United States	92
Loranthaceae				
Phoradendron flavescens	LF	Taken orally as a tea	United States	90
Lycopodiaceae				
Lycopodium annotinum	PL	Decoction is drunk	Soviet Union	92
Lythraceae				
Lawsonia inermis	—	—	India	192
Magnoliaceae				
Michelia champaca[b]	—	—	India	192
Malvaceae				
Gossypium herbaceum	RT	Decoction is drunk	South America, India	90, 92, 192
Hibiscus abelmoschus	FL	Infusion is drunk	Viti Islands	92
Hibiscus manihot[b]	—	—	India	192
Hibiscus rosa-sinensis	PT	Taken orally	India	99, 192
Hibiscus tiliaceus	FL	Smoked with tobacco	Melanesia, Gunantuna	92
Sphaeralcea munroana	RT	Decoction is drunk	United States	92
Urena lobata	LF	Leaves are chewed and juice is swallowed	New Ireland, India	90, 92, 192

Table II—*(Continued)*

Plant Name	Part[a]	Method of Use	Country	Reference
Melastomataceae				
Memecylon amplexicaule[b]	—	—	India	171
Menispermaceae				
Cissampelos pareira	RT	Water decoction is drunk	India	91
Curarea tecunarum	ST	Water extract of liana is drunk by male and female in gallon quantities	Brazil	172
Moraceae				
Cannabis sativa[b]	—	—	India	192
Moringaceae				
Moringa oleifera[b]	—	—	India	192
Myristicaceae				
Myristica fragrans[b]	—	—	India	192
Virola sp.	ST	—	Brazil	101
Myrsinaceae				
Embelia ribes	RT	Water decoction is drunk	India	91
Oleaceae				
Jasminum multiflorum[b]	—	—	India	171
Palmae				
Cocos nucifera	SD	Milk is drunk	Java	92
	FJ	Juice of ripe or unripe fruit is drunk	Pacific Islands	90
Licuala sp.	RB	Chewed and swallowed by males and females	Solomon Islands (Buka)	92
Pandanaceae				
Pandanus tectorius[b]	—	—	India	171
Papaveraceae				
Argemone mexicana[b]	—	—	India	171
Chelidonium majus	PL	Juice is drunk	Soviet Union	92
Phytolaccaceae				
Phytolacca decandra[b]	—	—	India	171
Piperaceae				
Piper aurantiacum[b]	—	—	India	192
Piper leptostachyum[b]	—	—	India	171
Piper longum[b]	—	—	India	171, 192
Piper nigrum[b]	—	—	India	171, 192
Plantaginaceae				
Plantago lanceolata	PL	Powdered plant in diet	Europe	90
Plumbaginaceae				
Plumbago indica[b]	—	—	India	171
Plumbago rosea[b]	—	—	India	192
Plumbago zeylanica	RT	Water decoction is drunk	India	91, 192
Polemoniaceae				
Phlox stansburyi	LF	Decoction is drunk	United States	92
Polygonaceae				
Eriogonum jamesii	RT	Boiled 30 min; cupful is drunk during menstruation to prevent conception; also used by males	United States	90, 92
Polygonum hydropiper	PL	Infusion is drunk	Europe	90
Polypodiaceae				
Asplenium adiantum-nigrum	—	—	India	90, 92, 171, 192
Dryopteris filix-mas	—	—	India	192
	—	Infusion is drunk	Tartarean women	92
	RT, SD	Used for sterility	Europe	90
Punicaceae				
Punica granatum[b]	—	—	India	171
Ranunculaceae				
Aconitum heterophyllum	RT	Water decoction is drunk daily	India	91
Paeonia officinalis	—	Decoction is drunk	Soviet Union	92
Rosaceae				
Geum macrophyllum	LF	Decoction is drunk	United States	92
Hagenia abyssinica[b]	—	—	India	192
Prunus emarginata	WD	Water decoction is drunk	United States	92
Prunus mahaleb[b]	—	—	India	192
Sanguisorba officinalis	PL	Mixed with normal diet	Europe	90
Rubiaceae				
Anthocephalus cadamba	—	—	India	171
Anthocephalus indicus	LF, FL	—	India	91
Randia spinosa	FR	—	India	91
Rutaceae				
Citrus maxima[b]	—	—	India	171
Citrus medica	FR	Water decoction is drunk	India	91
Salicaceae				
Populus alba	SB	Decoction of bark is drunk	Mediterranean	90, 92
Santalaceae				
Santalum album[b]	—	—	India	192
Sapindaceae				
Sapindus trifoliatus[b]	—	—	India	192

(continued)

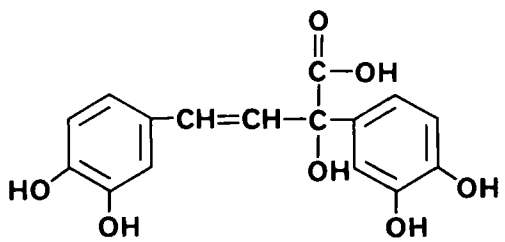
Table II—*(Continued)*

Plant Name	Part[a]	Method of Use	Country	Reference
Schizaeaceae				
Lygodium dichotomum	RT	Root is chewed with betel and some is swallowed	Solomon Islands (Buka)	90, 92
Scrophulariaceae				
Castilleja angustifolia	—	Decoction is drunk	United States	92
Solanaceae				
Datura metel	LF, FR	Water decoction is drunk	India	91
Solanum nigrum[b]	—	—	India	192
Withania somnifera[b]	—	—	India	192
Sterculiaceae				
Abroma agusta[b]	—	—	India	192
Tiliaceae				
Triumfetta bartramia[b]	—	—	India	192
Umbelliferae				
Anethum sowa	FR	Water decoction is drunk	India	91
Apium graveolens[b]	—	—	India	192
Carum carvi	FR	Water decoction is drunk	India	91
Carum roxburghianum	SD	Water decoction is drunk	India	91
Cicuta maculata	RT, RJ	Women chew and swallow roots on 4 consecutive days	United States	90, 92
Cuminum cyminum[b]	—	—	India	192
Ferula assa-foetida	—	—	India	192
Trachyspermum roxburghianum	—	—	India	171
Verbenaceae				
Callicarpa sp.	LF	Leaves are chewed and juice swallowed	Torres-Straits	90, 92
Callicarpa macrophylla[b]	—	—	India	171
Clerodendrum phlomidis[b]	—	—	India	171
Clerodendrum serratum	RT	Water decoction is drunk	India	91
Gmelina asiatica[b]	—	—	India	171
Stachytarpheta jamaicensis var. *indica*	—	—	India	171, 192
Vitex agnus-castus	PL	—	Europe	90
Vitex lagundi	RT	—	North Bougainville, Kurtachi	92
Vitex negundo	RT	Root scrapings are chewed with betel and swallowed	Solomon Islands (Buka)	90
	SD, RB	Water decoction is drunk	India	91, 192
Vitex trifolia[b]	—	—	India	192
Zingiberaceae				
Curcuma longa[b]	—	—	India	171, 192
Curcuma zedoaria[b]	—	—	India	171, 192
Globba marantia	—	—	Melanesia, Gunantuna	92

[a] EX = exudate, FJ = fruit juice, FL = flower, FR = fruit, FS = flower stems, IF = inflorescence, LF = leaf, PL = whole plant, PT = petals, RB = root bark, RJ = root juice, RT = roots, RZ = rhizome, SB = stem bark, SD = seed, SO = seed oil, SP = spadix, ST = stem, TU = tuber, WD = wood, and YS = young stems. [b] These plants have been stated to have "antifertility" properties, but it is possible that they may be abortifacients or emmenagogues.

(a) dried roots of the plant impaired development of the gonads and accessory sex organs of the immature male rat, and *(b)* injections of root extracts were at least 10 times more effective than oral administration of such extracts. Furthermore, similar effects could be produced in the mature animal. Several other groups also demonstrated antigonadotrophic activity for *L. ruderale* extracts (183–186), and Zeller *et al.* (187) showed that such extracts exert an anovulatory effect in hens.

In 1955, Graham and Noble (169) surveyed a number of plants for antigonadotrophic activity and showed this activity to be present not only in *L. ruderale* but also in *L. croccum, L. distichum, L. latifolium, L. arvense, L. officinale, Fatsia horrida, Arctostaphylos uva-ursi, Ambrosia artemisiifolia, Cnicus benedictus, Chenopodium album, Chamaelirium luteum, Amaranthus retroflexus, Borago officinalis,* and *Rubus idaeus.* The *Lithospermum* activity was found to be concentrated in the roots and increased in amounts from June to September (169). Furthermore, root extracts were highly active after a 4-year storage period, but extracts kept at 4° and pH 7.5 lost 50% of their potency after 1 week (169). Other members of the Boraginaceae, *i.e., Anchusa officinalis, Echium vulgare,* and *Symphytum officinale,* have also been shown to elicit antigonadotrophic activity (170).



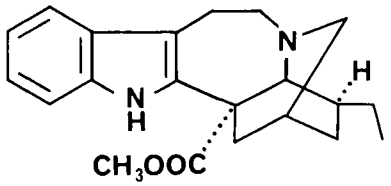
II (?): lithospermic acid

In 1958, Kemper and Loeser (188) showed that extracts of *L. officinale in vitro* and *in vivo* were capable of blocking the effect of pituitary hormones, such as hypophyseal gonadotrophins and thyrotrophin, as well as that of chorionic gonadotrophin, pregnant mare serum gonadotrophin, and prolactin.

In 1963, Johnson *et al.* (113) reported on a tentative structure for lithospermic acid (II), presumably the principal phenolic acid in members of the Boraginaceae eliciting antigonadotrophic activity. In the same year, this research group presented evidence that a very active polyphenoloxidase present in *L. ruderale* polymerizes the inactive lithospermic acid to an active polymer of unknown structure (112).

However, more recently Wagner *et al.* (115) gave evidence that "lithospermic acid" (from *S. officinale* and *Lycopus europaeus*) was a mixture of at least three different substances, based on chromatographic studies, thus refuting the structure work of Johnson *et al.* (113). They confirmed that a polyphenoloxidase preparation from the leaves of *L. europaeus* and *L. officinale* induced the lithospermic acid to acquire antigonadotrophic properties, and further showed that the addition of rutin or chlorogenic acid increased this activity.

Coronaridine—Meyer *et al.* (106) found that an aqueous ethanol extract from the roots of *Tabernaemontana heyneana* prevented pregnancy in adult female rats when the extract was administered orally. Investigation of this plant led to the isolation of a number of indole alkaloids, of which coronaridine (III) was found

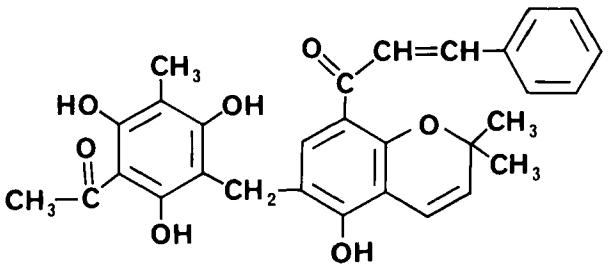


III: coronaridine

to be the active principle. Coronaridine, at a dose level of 5 mg/kg/day, prevented pregnancies and had a high degree of estrogenic activity.

Rutin—Cutting *et al.* (190) showed that a diet containing 0.1% of the flavonoid glycoside rutin impaired the fertility of female mice. But Wilson *et al.* (191) reported that a 1% rutin diet fed for 28–400 days did not modify the estrous cycle of female rats nor impair the fertility of male or female rats.

Rottlerin—The antifertility principle of *Mallotus philippinensis* has been identified as the chromene derivative rottlerin (IV) (168). At a dose level of 10 mg/kg, IV remained 100% effective for 10 days and 84% effective for 20 days; 20 mg/kg produced 100% infertility. Acetylrottlerin also was active, but isorottlerin was inactive (168).



IV: rottlerin

The isoflavones of known structure, as well as the coumestans, sterols, and cytotoxic agents, will be discussed in subsequent sections.

Antifertility Agents of Unknown Structure—Chou *et al.* (137) isolated two saponins having antifertility activity from *Gleditsia horrida*. One saponin was characterized as a triterpene attached to a single hexose sugar.

A new pyrone derivative of unknown structure, referred to as cirantin and isolated from *Citrus aurantium*, was reported to induce antifertility effects in two rabbits given oral doses of 0.75 mg/kg for 7 days (162). No further work has been found concerning this agent.

ABORTIFACIENTS, ECBOLICS, OXYTOCICS, AND EMMENAGOGUES

In this section, the literature concerning abortifacients, ecbolics, oxytocics, and emmenagogues will be reviewed relative to folkloric history, *in vitro* and *in vivo* animal studies (uterine stimulants), and human studies. When reviewing the folkloric uses of plants, it is often difficult to interpret differences between the four mentioned types of biological activities. For this review, any plant mentioned as being used to expel the fetus was considered an abortifacient. This definition groups together all ecbolics, oxytocics, and abortifacients simply as abortifacients. Also included in this category are plants said to be effective in "expelling the placenta," "useful in aiding childbirth," *etc.* Emmenagogues, on the other hand, were most often stated as such, but it is apparent that some authors consider the terms abortifacient and emmenagogue to be synonymous. We considered all plants mentioned to alter the menstrual cycle, unless specifically stated to be abortifacients, ecbolics, or oxytocics, to be emmenagogues.

There are many important reviews from which folkloric data were obtained (90, 91, 192–197), but the majority of plant names were found in minor references in the literature. The names of plants reported in the literature to have abortifacient (A) and emmenagogue (E) applications are presented in Table IV, together with the names of the plant parts used when this information was cited.

To determine whether or not plants having folkloric applications as abortifacients and/or emmenagogues might be confirmed, the literature was searched for plants whose extracts were shown to stimulate uterine tissue by means of *in vitro* or *in vivo* animal experiments. These data are presented in Table IV as (U) notations, together with the part of the plant from which the active extracts were prepared when such data were given.

Table III—Plants Evaluated in Animals or Humans for Antifertility Effects

Plant Name	Part Tested[a]	Type of Extract[b]	Dose and Route of Administration[c]	Species	Results	Reference
Acanthaceae						
Adhatoda vasica	LF	PE, ET, W	7 days before and 14 days during cohabitation in mice and 5 days after mating in rats, po	Mouse, rat	No activity	102
Amaranthaceae						
Amaranthus retroflexus	PL(?)	W	—	Rat	Antigonadotrophic activity *in vitro*	169
Anacardiaceae						
Semecarpus anacardium	SD	PE, ET, W	100 mg/kg/day on Days 1–4, po(?)	Rat	No inhibition of implantation	103
Annonaceae						
Artabotrys odoratissimus	LF	Fresh leaf	0.5–1.0 g/day for 3 days, po	Rat	Diestrus prolonged; degenerative changes in follicles; no body weight changes	104
Apocynaceae						
Apocynum androsaemifolium	PL	—	—	—	Anovulatory effect	171
Apocynum cannabinum	RT	—	—	—	Anovulatory effect	171
Catharanthus roseus	LF	Vinblastine	0.3–0.5 mg/kg, iv	Rabbit	66% reduction in normal fetuses	70
Stemmadenia galeottiana	FR	AC	Twice daily for 5 days, sc	Mouse	Number of litters reduced 44%	105
Tabernaemontana heyneana	RT	Coronaridine	5 mg/kg/day, po	Rat	Antifertility effect	106
Araceae						
Dieffenbachia seguine	SJ	Fresh stem sap, po	—	Mouse	Sterility in males 40–90 days; 30–50 days in females	95
	LF	—	—	Humans	Experimental	94

(*continued*)

Table III—*(Continued)*

Plant Name	Part Tested[a]	Type of Extract[b]	Dose and Route of Administration[c]	Species	Results	Reference
Lysichiton americanum	RT	ET/W	1–2% of diet, po	Mice	Inactive	117
Araliaceae						
Fatsia horrida	PL(?)	W	—	Rat	Antigonadotrophic effect *in vitro*	169
Asclepiadaceae						
Asclepias hallii	—	—	—	—	Anovulatory effect	171
Calotropis gigantea	RT	PE, ET, W	100 mg/kg/day on Days 1–4, po(?)	Rat	No inhibition of implantation	103
Calotropis procera	LF	PE, ET, W	100 mg/kg on Days 1–7, po	Rat	No inhibition of implantation	108
Daemia extensa	LF	In ration	po for 4 weeks; 3 g/day for rats; 9 g/day for guinea pigs	Rat, guinea pig	No effect on fertility	127
Marsdenia cundurango	BK	—	—	—	Anovulatory effect	171
Berberidaceae						
Berberis vulgaris	—	—	—	—	Anovulatory effect	171
Podophyllum peltatum	RT, RZ	Podophyllotoxin	0.25 mg, sc	Mouse	No pregnancies when treated on Day 3 or later	109
	RT, RZ	Podophyllin	5 g/ml in petroleum jelly, 0.2 ml instilled in uterus	Rat	No effect on implantation	110
Boraginaceae						
Anchusa officinalis	PL	W	—	Mouse	Antigonadotrophic activity	170
Borago officinalis	PL(?)	W	—	Rat	Antigonadotrophic activity *in vitro*	169
Echium vulgare	PL	W	—	Mouse	Antigonadotrophic activity	170
Lithospermum arvense	PX	W	—	Rat	Antigonadotrophic activity *in vitro*	169
Lithospermum croceum	PX, RT	W	—	Rat	Antigonadotrophic activity *in vitro*	169
Lithospermum distichum	PX, RT	W	—	Rat	Antigonadotrophic activity *in vitro*	169
Lithospermum latifolium	PX, RT	W	—	Rat	Antigonadotrophic activity *in vitro*	169
Lithospermum officinale	PX	W	—	Rat	Antigonadotrophic activity *in vitro*	169
	LF	W	—	Rat, guinea pig	Antigonadotrophic activity *in vitro*; diestrus in rats	188
	PL	W	1 g/day, po	Mouse	Inhibited vaginal cornification	114
Lithospermum ruderale	PX, RT	W	—	Rat	Antigonadotrophic activity *in vitro*	169
	RT	—	po	Mouse	Cessation of estrous cycles	188
	PX	—	—	Mouse	Depressed estrous cycles	180
	RT	Oxidized lithospermic acid	sc or po daily for 6 days (rat); daily injections for 7 days (hen)	Rat, hen	Antigonadotrophic activity (rat); anovulatory activity (hen)	112
	—	—	In ration, 15% of diet	Mouse	Produced anestrus; nonestrogenic and nonandrogenic	111
Pulmonaria officinalis	PL	W	—	Rat	Antigonadotrophic activity *in vitro*	115
Symphytum officinale	PL	W	—	Rat	Antigonadotrophic activity *in vitro*	115
	RT	Oxidized lithospermic acid	6–12 mg/kg, sc	Mouse	Antigonadotrophic activity increased by rutin or chlorogenic acid	115
Bromeliaceae						
Ananas comosus	RZ, FR	PE, ET, W	"Suitable amount," po	Mouse	Antifertility activity in PE and ET extracts	102
	FR	Juice	50 ml/kg on Days 1–7	Rat	60% inhibition of implantation	116
Caprifoliaceae						
Lonicera ciliosa	LF	ET/W	Dry extract as 1–2% of diet, po	Mouse	45% reduction in litters	117
Caricaceae						
Carica papaya	FP	PE, ET, W	100–500 mg/kg on Days 1–7, po	Rat	Variable inhibition of implantation	118
	SD	In ration	*Ad libitum*	Mouse	Reduced fertility with toxicity	119

Table III—*(Continued)*

Plant Name	Part Tested[a]	Type of Extract[b]	Dose and Route of Administration[c]	Species	Results	Reference
Caryophyllaceae						
Dianthus superbus	PL	W, AC	0.1 ml twice daily for 5 days, sc	Mouse	Interferes with early pregnancy; may be an estrogenic effect	120
	PL	W, AC	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Decreased number of litters; post-copulatory effect	121
Vaccaria pyramidata	PL	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Decreased number of litters; no post-copulatory effect	121
Chenopodiaceae						
Chenopodium album	LF	In ration	3 g/day for 4 weeks, po	Rat	No effect on fertility	127
	LF	In ration	9 g/day for 4 weeks, po	Guinea pig	No effect on fertility	127
	PL(?)	W	—	Rat	Antigonadotrophic effect *in vitro*	169
Combretaceae						
Terminalia catappa	—	—	—	—	Antifertility effect	171
Compositae						
Ambrosia artemisifolia	PL(?)	W	—	Rat	Antigonadotrophic activity *in vitro*	169
Artemisia sp.	PL(?)	Santonin	Added to ration, po	Mouse	Delay in estrus, ovulation, and onset of mating	119
Artemisia maritima	—	—	—	—	Anti-implantation effect	171
Cnicus benedictus	PL(?)	W	—	Rat	Antigonadotrophic activity *in vitro*	169
Cnicus spicatus	PL	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Decreased number of litters	121
Grindelia sp.	PL	—	—	—	Anovulatory effect	171
Solidago odora	LF	—	—	—	Anovulatory effect	171
Stevia rebaudiana[d]	PL	W	10 ml of a 5% decoction for 6 days during mating	Rat	Fertility reduced 57–79%	122
Cruciferae						
Capsella bursa-pastoris	PL	In ration	20–40% of ration	Mouse	40% in ration impeded ovulation	123
Isatis oblongata	PL	W (distilled with limestone)	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Decreased number of litters	121
Raphanus sativus	PL	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Decreased number of litters	121
Cucurbitaceae						
Ecballium elaterium	PL, FR	Dihydro-elatericin A	20–100 mg/kg/day, po	Mouse	Inhibition of ovulation at 100 mg/kg	124
Luffa cylindrica	PL	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Decreased number of litters	121
Momordica charantia	LF	W	250–500 mg/day on Days 1–7, po	Rat	No activity	125
Cupressaceae						
Thuja occidentalis	LF	—	—	—	Anovulatory effect	171
Ericaceae						
Arctostaphylos uva-ursi	PL(?)	W	—	Rat	Antigonadotrophic activity *in vitro*	169
Euphorbiaceae						
Euphorbia lathyris	PL	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Decreased number of litters; no post-copulatory activity	121
Jatropha curcas	FR, SD	In ration	3.3% of ration for 25 days, po	Rat	Complete inhibition of reproduction	126
Mallotus philippinensis	TR	In ration	Daily for 4 weeks, po; rat 0.75 g/day, guinea pig 3 g/day	Rat, guinea pig	Decreased mating in rats and guinea pigs	127
	TR	Rottlerin	20–840 mg/kg, po	Rat	Prevented mating	168
	—	—	—	—	Anti-implantation effect	171
	SD	PE, ET, W	7 days before and 14 days during cohabitation in mice and 5 days after mating in rats, po	Mouse, rat	No activity	102
Ricinus communis	SD	PE, ET, W	100–500 mg/kg on Days 1–7, po	Rat	No inhibition of implantation	118
Stillingia sylvatica	RT	—	—	—	Anovulatory effect	171
Gramineae						

(continued)

Table III—*(Continued)*

Plant Name	Part Tested[a]	Type of Extract[b]	Dose and Route of Administration[c]	Species	Results	Reference
Dendrocalamus strictus	LF	PE, ET, W	100 mg/kg on Days 1–7, po	Rat	No inhibition of implantation	108
Labiatae						
Hyssopus officinalis	PL	W	—	Rat	Antigonadotrophic	115
Lycopus europaeus	LF	Oxidized lithospermic acid	—	Mouse	Antigonadotrophic activity increased by rutin or chlorogenic acid	115
Lycopus lucidus	PL	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Decreased number of litters; postcopulatory activity	121
Majorana hortensis	PL	W	—	Rat	Antigonadotrophic	115
Marrubium officinalis	PL	W	—	Rat	Antigonadotrophic	115
Melissa officinalis	PL	W	—	Rat	Antigonadotrophic	115
Mentha piperita	PL	W	—	Rat	Antigonadotrophic	115
Ocimum sanctum	LF	PE, BZ, E, AC ET	100–200 mg/kg, po	Rat	80% antifertility for BZ extract, 60% for PE extract, others inactive	99
Orthosiphon stamineus	PL	W	—	Rat	Antigonadotrophic	115
Rosmarinus officinalis	PL	W	—	Rat	Antigonadotrophic	115
Salvia officinalis	PL	W	—	Rat	Antigonadotrophic	115
Thymus serpyllum	PL	W	—	Rat	Antigonadotrophic	115
Thymus vulgaris	PL	W	—	Rat	Antigonadotrophic	115
Lecythidaceae						
Combretodendron africanum	SB	W	Various doses, iv and sc	Rat, rabbit	Tannins and saponins inhibited estrous cycle, mating, and pregnancy	130
Leguminosae						
Abrus precatorius	LF	PE, ET, W	7 days before and 14 days during cohabitation in mice and 5 days after mating in rats, po	Mouse, rat	No antifertility activity	102
	SD	PE	150 mg/rat for 20 days before mating or on Days 1–5	Rat, mouse	Antifertility effects	131
	SD	PE, ET, W	100 mg/kg, po; PE, ET = Days 1–4; W = Days 1–7	Rat	No significant inhibition of implantation	103
	RT	PE, ET	100 mg/kg on Days 1–5, po	Rat	Prevention of nidation; ET extract has antiestrogenic activity	100
	SD	PE	7 days before and 14 days during cohabitation in mice and 5 days after mating in rats, po	Mouse, rat	Antifertility activity but toxic	102
Acacia koa	LF	ET, W	Twice daily for 5 days, sc	Mouse	Number of litters reduced 88–100%, but toxic	105
Astragalus glycyphyllus	PL	W	Continuous oral dosage	Rat	Increased duration of estrous phase of cycle	132
Butea frondosa	SD	ET, CH, W	10 mg–1 g/kg/day for 15 days, po	Rat	No change in estrous cycle; delayed mating with higher doses	133
	SD	ET, CH, W	10–1500 mg/kg/day, po; 100 mg/kg on Days 1–5, sc	Mouse, rat	Antifertility effect	133
	PT	ET	10–200 mg/kg	Mouse, rat	Antifertility effect	134
	PT, SD	ET	Various doses, parenteral	Mouse, rat	No estrogenic activity	135
Butea monosperma	SD	ET	25–200 mg/kg for 7 days, po	Rat	No inhibition of implantation	136
	FL	PE, ET, W	100 mg/kg/day on Days 1–7	Rat	No inhibition of implantation	116
Butea parviflora	SD	PE, ET, W	100 mg/kg on Days 1–7, po	Rat	No inhibition of implantation	108
Clitoria ternatea	FR	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Decreased number of litters	121
Gleditsia horrida	FR	ET	Doses not stated, given for 5 days, sc	Mouse	Two saponins and sugars produced antifertility effect	137
Medicago sativa	IF	E, CH, acid	Not stated	Rat	E extract was estrogenic, CH extract was antiestrogenic, acid extract inter-	141

Table III—*(Continued)*

Plant Name	Part Tested[a]	Type of Extract[b]	Dose and Route of Administration[c]	Species	Results	Reference
					fered with seminal vesicle growth and potentiated action of estrogens	
	—	—	—	Rat	Antigonadotrophic	140
	PL	In ration	po	Rabbits (male)	Degenerative changes in ova after mating	142
Phaseolus aureus	PL	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Decreased number of litters; postcopulatory activity	121
Pisum sativum	SO	*m*-Xylohydroquinone	On Days 16 and 21 of cycle, po	Human	Reduction in relative number of pregnancies	143, 144, 146
	SD	In ration	20–30% of diet	Rat	20% decreased and 30% stopped litter formation	148
	SD	—	po	Rat	Decreased fertility	147
	SO	—	im monthly	Human	Postponed pregnancy	147
	SO	*m*-Xylohydroquinone	300–350 mg on Days 16 and 21 of cycle, monthly, po	Human	Reduction in number of pregnancies	147, 148
Psoralea corylifolia	SD	In ration	0.35 g/day for 37–77 days, po	Mouse	Fertility impaired; estrogenic effect Psoralen was not the active principle	149
Sesbania sesban	FL	W	7 days before and 14 days during cohabitation in mice and 5 days after mating in rats, po	Mouse, rat	Antifertility effect	102
	LF	W	7 days before and 14 days during cohabitation in mice and 5 days after mating in rats, po	Mouse, rat	No activity	102
Trifolium subterraneum	PL	In ration	*Ad libitum*, po	Sheep	Impaired release of luteinizing hormone by isoflavones; morphological changes in cervix	150–152
Uraria lagopoides	PL	PE, ET, W	100 mg/kg on Days 1–7, po	Rat	50% inhibition of implantation with W extract	103
Liliaceae						
Aloe barbadensis	LF	W	7 days before and 14 days during cohabitation in mice and 5 days after mating in rats, po	Mouse, rat	Antifertility activity	102
	FP	W	100–500 mg/kg on Days 1–7	Rat	No significant antiimplantation effect	116
Asagraea officinalis	SD	—	—	—	Anovulatory effect	171
Chamaelirium luteum	PL(?)	W	—	Rat	Antigonadotrophic activity *in vitro*	169
Colchicum autumnale	CO	Demecolcine	0.1–5.0 mg/kg, sc	Rabbit	Toxic to fetus when given after implantation	70
	CO	Colchicine	0.5 mg/ml saline; 0.2 ml instilled into one uterine horn	Rat	Few fetuses both horns	110
Gloriosa superba	TU	PE, ET, W	10–100 mg/kg on Days 1–7, po	Rat	No inhibition of implantation; toxic	108
Paris polyphylla	PL	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Decreased number of litters	121
Smilax bona-nox	RT	—	—	—	Anovulatory effect	171
Veratrum californicum	PL	In ration	*Ad libitum*, po	Sheep	Prolonged gestation associated with cyclopic fetuses	153
Magnoliaceae						
Magnolia virginiana	BK	—	—	—	Anovulatory effect	171
Michelia champaca	RT	PE, ET, W	100 mg/kg on Days 1–7, po	Rat	No inhibition of implantation	108
Malvaceae						
Gossypium herbaceum	SD, ST, SB, RB	PE, ET, W	100 mg/kg on Days 1–4 or 1–7	Rat	No significant antiimplantation effect	116
Hibiscus rosa-sinensis	PT	PE, BZ, E, ET	100–200 mg/kg, po	Rat	80% inhibition of implantation by BZ extract	99
	PT	—	—	—	Anovulatory effect	171

(continued)

Table III—*(Continued)*

Plant Name	Part Tested[a]	Type of Extract[b]	Dose and Route of Administration[c]	Species	Results	Reference
Menispermaceae						
Chondodendron tomentosum	RT	—	—	—	Anovulatory effect	171
Stephania hernandifolia	RZ	PE, ET	7 days before and 14 days during cohabitation in mice and 5 days after mating in rats; po	Mouse, rat	Antifertility effect with ET extract; increased fertility with PE extract	102
Moraceae						
Ficus pumila	LF	W	Twice daily for 5 days, sc	Mouse	61% reduction in litters	105
Moringaceae						
Moringa pterygosperma	SB	PE, ET, W	7 days before and 14 days during cohabitation in mice and 5 days after mating in rats; po	Mouse, rat	No effect by any of the extracts	102
Musaceae						
Ensete superbum	SD	AA	Various dosages for varying periods prior to and after mating, po	Mouse, rat, hamster, rabbit, guinea pig	Anti-implantational and postimplantational effects	155
Myrsinaceae						
Embelia ribes	PL	—	The following is taken in equally divided doses daily for 22 days while abstaining from intercourse: 4 drams active principle of *Embelia ribes*, 4 drams *Piper longum*, 2 drams assafoetida, and 4 drams borax	Human	Prevention of conception for 1 year	138
Myrtaceae						
Metrosideros collina	LF	W	Twice daily for 5 days, sc	Mouse	53% reduction in litters	105
Palmae						
Areca catechu	FR	PE, ET, W	100–500 mg/kg on Days 1–7, po	Rat	Inhibition of implantation with higher dose	118
	PL	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Inactive	121
Papaveraceae						
Argemone glauca	IF	ET	Twice daily for 5 days, sc	Mouse	Reduced litters by 78%	105
	PL	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Inactive	121
Pinaceae						
Pinus ponderosa	LF	VO, W, AC	In ration	Mouse	Complete disruption of pregnancy with W extract	156
	LF[e]	W	In ration	Mouse	See Footnote *e*	145
Piperaceae						
Peperomia sp.	LF, ST	W	Twice daily for 5 days, sc	Mouse	43–50% reduction of litters	105
Piper betle	LF, RT	PE, ET, W	7 days before and 14 days during cohabitation in mice and 5 days after mating in rats, po	Mouse, rat	Inactive	102
Piper latifolium	RT	—	—	—	Anovulatory effect	171
Piper longum	FR	—	See *Embelia ribes* (Myrsinaceae)	Human	Prevents conception for 1 year	138
	LF, RT	PE, ET, W	7 days before and 14 days during cohabitation in mice and 5 days after mating in rats, po	Mouse, rat	Inactive	102
Plumbaginaceae						
Plumbago zeylanica	RT	PE, ET, W	100 mg/kg on Days 1–7, po	Rat	No inhibition of implantation	108
Polygonaceae						
Polygonum hydropiper	PL	In ration	1 g/day	Mouse	Impaired fertility in mice	157
	PL	In ration	9 g/day	Guinea pig	Sterility in female guinea pigs	157
	RT	ET	100 mg/kg on Days 1–7	Rat	80% inhibition of implantation with PE fraction of ET extract	158

Table III—(*Continued*)

Plant Name	Part Tested[a]	Type of Extract[b]	Dose and Route of Administration[c]	Species	Results	Reference
Polygonum multiflorum	PL	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Decreased number of litters	121
Polypodiaceae						
Aspidium sp.	LF, ST	In ration	*Ad libitum*	Mouse	Reduced fertility with high toxicity	119
Dryopteris filix-mas	—	—	—	—	Anovulatory effect	171
Punicaceae						
Punica granatum	PC	In ration	3 g/day for 4 weeks, po	Rat	Infertile matings	127
	PC	In ration	9 g/day for 4 weeks, po	Guinea pig	Infertile matings	127
Ranunculaceae						
Aconitum napellus	RT	—	—	—	Anovulatory effect	171
Cimicifuga racemosa	RT	—	—	—	Anovulatory effect	171
Paeonia sp.	PL	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Decreased number of litters	121
Paeonia moutan	PL	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Inactive	121
Rosaceae						
Hagenia abyssinica	LF, ST	In ration	*Ad libitum*	Mouse	Reduced fertility with toxicity	119
Prunus emarginata	WD	EW	1–2% of ration, po	Mouse	45% reduction of litters	117
Pyrus communis	SB	W	po and im	Mouse, rat, dog	Pregnancy interrupted at all stages	159
Quillaja saponaria	BK	—	—	—	Anovulatory effect	171
Rubus idaeus	LF	W	—	Rat	Antigonadotrophic	169
Sanguisorba officinalis	PL	In ration	20–30% of diet, po	Mouse	Prolongation of diestrus	160
	PL	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Inactive	121
Rubiaceae						
Adina cordifolia	LF	ET	100 mg/day after copulation for 5 days, po	Rat	No effect	161
Randia dumetorum	FR	PE, ET, W	100 mg/kg on Days 1–7, po(?)	Rat	No significant inhibition of implantation	103
Rubia cordifolia	PL	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Decreased number of litters	121
Rutaceae						
Citrus aurantium	PC	Cirantin	0.75 mg/kg for 7 days, po	Rabbit	No pregnancies after several matings	162
Evodia rutaecarpa	PL	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Decreased number of litters	121
Salicaceae						
Salix sp.	BK	—	—	—	Anovulatory effect	171
Saxifragaceae						
Hydrangea arborescens	RT	—	—	—	Anovulatory effect	171
Scrophulariaceae						
Rehmannia glutinosa	PL	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Decreased number of litters	121
Simaroubaceae						
Brucea amarissima	SD	ET	Twice daily for 5 days, sc	Mouse	100% reduction in litters	105
Simarouba amara	BK	—	—	—	Anovulatory effect	171
Solanaceae						
Nicotiana tabacum	LF	Smoking	Smoking	Human	Alters ovarian cycle	163
	LF	Nicotine	Implant *in utero*	Rat	Increase in number of stillborn	164
Solanum dulcamara	TW	—	—	—	Anovulatory effect	171
Solanum xanthocarpum	ST, LF	In ration	Rats, 3 g/day; guinea pigs, 9 g/day for 4 weeks, po	Rat, guinea pig	No effect	127
Withania somnifera	RT	In ration	25 mg/day, po	Mouse	Reduction in fertility	165
Stemonaceae						
Stemona japonica	PL	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Decreased number of litters	121
Taxaceae						
Taxus baccata	LF	PE, ET, W	50–100 mg/kg on Days 1–7 with W extract and on Days 1–5 with PE and ET extracts	Rat	60% infertility with PE and W extracts	166
	ST	PE, ET, W	100 mg/kg on Days 1–4, po(?)	Rat	No significant anti-implantation effect	103

(*continued*)

Table III—(*Continued*)

Plant Name	Part Tested[a]	Type of Extract[b]	Dose and Route of Administration[c]	Species	Results	Reference
	LF	PE, ET, W	100 mg/kg on Days 1–4, po(?)	Rat	55% inhibition of implantation with W extract	103
	LF	In ration	Rat, 3 g/day; guinea pig, 9 g/day, for 4 weeks, po	Rat, guinea pig	No infertility effect	127
Thymelaeaceae						
Daphne genkwa	PL	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Decreased number of litters	121
Tiliaceae						
Grewia asiatica	SD	PE, ET, W	500 mg/kg on Days 1–7, po	Rat	40–66.6% inhibition of implantation	118
Umbelliferae						
Apium graveolens	SD	PE, ET, W	100 mg/kg on Days 1–7	Rat	No inhibition of implantation	116
Carum carvi	SD	In ration	3 g/day/rat; 9 g/day/guinea pig, for 4 weeks, po	Rat, guinea pig	No effect	127
Daucus carota	SD	PE, ET, W	100–500 mg/kg on Days 1–7, po	Rat	Variable inhibition of implantation	118
	SD	PE, ET, W	20–100 mg/kg on Days 1–7, po	Rat	Various results with different chromatographic fractions	52
Ferula assa-foetida	R	Resin	See *Embelia ribes* (Myrsinaceae)	Human	Prevention of conception for 1 year	138
Leptotaenia reticulata	—	—	—	—	Anovulatory effect	171
Siler divaricatum	PL	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Decreased number of litters	121
Verbenaceae						
Clerodendrum uncinatum	PL	W	—	Rat	Antigonadotrophic	115
Verbena hastata	PL	—	—	—	Anovulatory effect	171
Verbena officinalis	PL	W	—	Rat	Antigonadotrophic	115
	PL	W	0.05–0.2 ml twice daily for 5 days, sc	Mouse	Inactive	121
Vitex agnus-castus	SD	In ration	3 g/day/rat; 9 g/day/guinea pig 4 weeks, po	Rat, guinea pig	No effect	127

[a] BK = bark, CO = corm, FL = flower, FP = fruit pulp, FR = fruit, IF = inflorescence, LF = leaf, PC = pericarp, PL = whole plant, PT = petals, PX = aerial parts, R = resin, RB = root bark, RT = root, RZ = rhizome, SB = stem bark, SD = seed, SJ = stem juice, SO = seed oil, ST = stems, TR = trichomes, TU = tuber, TW = twigs, and WD = wood. [b] Extraction solvents were: AA, absolute ethanol; AC, acetone; BZ, benzene; CH, chloroform; E, ether; ET, 95% ethanol; EW, ethanol–water (1:1); ME, methanol; PE, petroleum ether; VO, volatile oil; and W, water. [c] Routes of administration were: im, intramuscular; ip, intraperitoneal; iv, intravenous; po, oral; and sc, subcutaneous. [d] This activity could not be confirmed in at least two laboratories (128, 129). [e] Activity suspected to be due to mycotoxins produced by fungi parasitizing the pine needles (145).

Table IV—Emmenagogue, Abortifacient, and Uterine Stimulant Plants and Their Active Principles Where Known

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
Acanthaceae				
Adhatoda vasica	A, E	LF	192, 193	—
Dipteracanthus suffruticosa	A	RT	192, 193	—
Ruellia suffruticosa	See *Dipteracanthus suffruticosa*			
Strobilanthes crispus	U	LF	199	—
Agavaceae				
Agave americana	A	—	192	—
	E	LJ	193	—
	E	PL, JU	194	—
Agave lecheguilla	U	—	200	Crude saponin
Yucca gloriosa	U	—	201	—
Aizoaceae				
Carpobrotus edulis	A	FR	194	—
Trianthema decandra	A	PL	193	—
Trianthema monogyna	See *Trianthema portulacastrum*			
Trianthema pentandra	See *Trianthema decandra*			
Trianthema portulacastrum	A	—	192	—
	A	RT	193	—
Alangiaceae				
Alangium lamarckii	U	LF	202	Total alkaloids
	I	—	203	Emetine (CXXVIII)
Alismataceae				
Sagittaria sagittifolia	A	—	192	—
Amaranthaceae				
Achyranthes aspera	A	—	204	—
	A	LJ	192, 193	—
Alternanthera sessilis	A	—	194	—
Amaranthus gangeticus	E	LF	193	—
Amaranthus thunbergii	A	PL	194	—
Bragantia tomentosa	A	—	192	—

Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
	E	PL	193	—
Amaryllidaceae				
Clivia miniata	A	RT	194	—
	I	—	204–210	Lycorine (CXXVII)
Crinum sp.	I	—	211	Hordenine (VI)
	I	—	205–210, 218	Lycorine
Crinum asiaticum	A	—	192	—
	I	—	205–210, 218	Lycorine
Pancratium sp.	I	—	211, 310	Hordenine
	I	—	212–217, 312	Tyramine (IX)
Pancratium sickenbergi	U	BU	218	—
	I	—	205–210, 218	Lycorine
Anacardiaceae				
Anacardium occidentale	U	TE	219	—
Lannea schimperi	A	BK	220	—
Rhus coriaria	U	—	221	—
Rhus glaucescens	See *Rhus longipes*			
Rhus incana	See *Rhus longipes*			
Rhus incana var. *cuneidoliolaya*	See *Rhus longipes*			
Rhus longipes	A	PL	222	—
Rhus ruzizensis	See *Rhus longipes*			
Rhus succesanea	I	—	223	Ellagic acid (CXXXIII)
Rhus toxicodendron	U	—	224	—
Rhus villosa	See *Rhus longipes*			
Semecarpus anacardium	A	—	192	—
	A	SD	193	—
	E	SD	193	—
Spondias lutea	U	SB	219	—
Tapirira guianensis	U	SB	219	—
Annonaceae				
Annona muricata	U	LS	225	—
Annona squamosa	A	—	192	—
	A	SD	193	—
	U	—	219	—
Unona setigera	See *Uvaria rufa*			
Uvaria ridleyi	See *Uvaria rufa*			
Uvaria rufa	A	RT	195	—
Uvaria setigera	See *Uvaria rufa*			
Uvaria solanifolia	See *Uvaria rufa*			
Apocynaceae				
Aganosma marginata	A	—	192	—
	E	PL, RT	193	—
Alstonia constricta	U	BK	226, 227	Total alkaloids
	I	—	228–232	Reserpine (LXXXIX)
Alstonia scholaris	A	—	192	—
	E	BK	193	—
	I	—	228–232	Reserpine
Anodendron paniculatum	A	—	192	—
	A	RT	90	—
Carissa edulis	A	RT	233	—
Catharanthus roseus	A	RT	234	—
Cerbera odollam	A	SD, FR	193	—
	A	—	192	—
Ervatamia coronaria	A	—	192	—
	E	RT	193	—
Forsteronia floribunda	U	LS	225	—
Holarrhena antidysenterica	E	SD	91	—
Holarrhena febrifuga	A	RT, LF	194	—
	E	LF	194	—
Nerium indicum	A	RT	193	—
	E	RT	193	—
	U	—	201	—
Nerium odorum	See *Nerium indicum*			
Nerium oleander	U	—	235, 236	—
Peschiera affinis	U	RB	219	—
Pleioceras barteri	A	FR, SD, RB, LF	196	—
	E	FR, SD, RB, LF	196	—
Plumeria acuminata	A	—	193	See also *Plumeria rubra* f. *acutifolia*
Plumeria bracteata	U	RB	219	—
Plumeria rubra	A	FR	194	—
	E	FR	194	—
Plumeria rubra f. *acutifolia*	A	—	193	—
Rauvolfia serpentina	A	RT	91, 193	—
	A	—	192	—

(*continued*)

Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
	U	RT	237	Total alkaloids
	I	RT	228–232	Reserpine
	I	RT	238	Neoajmaline (ajmaline) (XCI)
	I	—	239	Corynanthine (LXXXVIII)
Rauvolfia vomitoria	A	LF	194	—
	E	LF	194	—
	I	—	228–232	Reserpine
Strophanthus sp.	I	—	240–244	Strophanthin (CXLIII)
Tabernanthe iboga	I	—	245, 246	Ibogaine (LXXXIII)
Thevetia nereifolia	See *Thevetia peruviana*			
Thevetia peruviana	A	SD	192, 193	—
	A	SD, PL	194	—
	E	SD	193	—
	U	—	247	—
	I	—	248	Thevetin (CXLIV)
Vallaris solanacea	U	LF	249	Crude glycosidic mixture
Vinca erecta	U	—	250	Alkaloid mixture
	H	—	257, 258	Vincamine (XC)
	I	—	251	Ervamine (LXXXV)
	I	—	252, 256	Vincamine
	I	—	251, 254, 255	Vineridine (XCV)
	I	—	251	Vinervine (LXXXVI)
Vinca major	A	—	194	—
	A	RT	259	—
	I	—	228–232	Reserpine
Araceae				
Acorus calamus	A	—	192	—
	E	RZ	193	—
Amorphophallus campanulatus	A	—	192	—
	E	RT	193	—
Cyrtosperma griffithii	See *Cyrtosperma merkusii*			
Cyrtosperma merkusii	A	SP	195	—
Dieffenbachia seguine	U	LS	225	—
Dracontium polyphyllum	A	—	192	—
	E	PL	193	—
Dracunculus vulgaris	E	PL	194	—
Lasia merkusii	See *Cyrtosperma merkusii*			
Scindapsus officinalis	E	FR	91	—
Araliaceae				
Cussonia arborea	E	RT	194	—
Hedera arborea	See *Hedera helix*			
Hedera helix	E	EX	194	—
	E	LF	197	—
Aristolochiaceae				
Aristolochia sp.	I	—	260, 261	Aristolochic acid (CL)
Aristolochia bracteata	A	—	192	—
	E	PL	193	—
Aristolochia clematitis	E	RZ	197	—
	U	—	262	—
	I	—	260, 261	Aristolochic acid
Aristolochia indica	A	—	192	—
	A	RT, PL	193	—
	A	RT	91	—
	I	—	260, 261	Aristolochic acid
Aristolochia rotunda	E	RT	197	—
	I	—	260, 261	Aristolochic acid
Asclepiadaceae				
Asclepias tuberosa	U	RT	263, 264	—
Calotropis gigantea	A	LX	265	—
	A	—	192	—
	E	LX	193	—
	U	LX	265, 266	—
	U	TW	204	—
Calotropis procera	A	—	192, 267	—
	A	PL	192, 194	—
	E	LX	193	—
	U	RT	268	—
Chlorocodon whitelii	A	PL	194	—
Daemia extensa	A	—	192	—
	E	LF	90	—
	I	—	269	Uncharacterized glycoside
Gymnema sylvestre	A	LF	194	—
	I	—	270	Betaine (CXV)
Omphalogonus nigritanus	A	LF, RT	196	—
Pergularia extensa	A	LF	196	—
	A	—	192	—
	E	LF	196	—
Tylophora asthmatica	A	—	192	—
Xysmalobium undulatum	A	RT	194	—

Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
	U	RT	271	Uzarine
Berberidaceae				
Berberis sp.	I	—	272, 274–280	Berberine (umbellatine) (LII)
Berberis amurensis	U	RT	277	—
	I	—	273	Jatrorrhizine (LIV)
Berberis aristata	A	—	192	—
	E	RT, WD	193	—
	I	—	274–280	Berberine
	I	—	280, 281, 597, 599	Palmatine (LV)
Berberis lycium	I	—	282	Berberine (umbellatine)
	I	—	274–280	Erysotrine (CXXIII)
Berberis thunbergii	U	—	283	—
	I	—	274, 280	Berberine
	I	—	284	Columbamine (isocorypalmine) (LIII)
	I	—	273	Jatrorrhizine
	I	—	281	Palmatine
Berberis vulgaris	U	SB	278, 285	Total alkaloids
	U	LF	286	—
	U	BK	287	—
	U	PL	288	—
	I	—	274–280	Berberine
	I	—	284	Columbamine
	I	—	273	Jatrorrhizine
	I	—	281	Palmatine
Caulophyllum thalictroides	A	RT	90	—
	E	RT	90, 289	—
Caulophyllum thalictroides var. *robustum*	U	—	283	—
Epimedium sempervirens	U	—	283	—
Leontice alberti	U	—	290	Alkaloid mixture
Nandina domestica	I	—	274–280	Berberine
	I	—	273	Jatrorrhizine
	I	—	291	Nandinine (XLIX)
Betulaceae				
Betula paltyphylla	U	—	283	—
Bignoniaceae				
Dolichandrone falcata	A	—	192	—
	A	FR, PL	193	—
Bombacaceae				
Adansonia digitata	A	—	192	—
	E	FS	193	—
Bombax malabaricum	U	SD	292, 293	—
Boraginaceae				
Cordia quarensis	A	RT	194	—
Heliotropium angiospermum	U	LS	294	—
Heliotropium indicum	A	FL	193	—
	A	—	192	—
	E	FL	193	—
	U	RT	295	—
	I	—	296	Retrornecine (LXXIII)
Tournefortia hirsutissima	U	LS	294	—
Bromeliaceae				
Ananas comosus	A	—	192	—
	A	LF, FR	193	—
	A	FR, JU	194	—
	E	LF, FR	193	—
	E	FR	194	—
Ananas sativus	A	LF, FR	193	—
	I	—	297–309	5-Hydroxytryptamine (LXXVII)
Buddlejaceae				
Buddleja asiatica	A	PL	193	—
	A	—	192	—
Burseraceae				
Balsamodendron mukul	A	—	192	See also *Commiphora mukul*
	E	—	193	—
Balsamodendron myrrha	A	—	192	See also *Commiphora myrrha*
Boswellia glabra	A	—	192	—
	E	BA, RA	193	—
Boswellia serrata	A	—	192	—
	E	VO, GU	193	—
Commiphora mukul	A	—	192	—
	E	GU, RE	193	—
Commiphora myrrha	A	—	192	—
	E	GU	193	—

(*continued*)

Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
Cactaceae				
Harrisia gracillis	U	LS	294	—
Lophophora williamsii	I	PL	211, 310	Hordenine
	I	—	311	Mescaline (VII)
	I	—	212, 217, 312	Tyramine
Calycanthaceae				
Calycanthus sp.	I	—	313	Calycanthine (CXIX)
Cannabaceae				
Cannabis sativa	A	—	192	—
	A	SD	193	—
	E	PL	193	—
	U	—	219, 314–316	—
	I	—	317	Nicotine (X)
Capparidaceae				
Cadaba farinosa	A	—	192	—
	E	LF, RT	193	—
	E	LF	194	—
Cadaba indica	See *Cadaba farinosa*			
Cadaba trifoliata	A	—	192	—
	E	RT, LF	193	—
Capparis aphylla	See *Capparis decidua*			
Capparis decidua	A	—	192	—
	E	PL	193	—
Capparis spinosa	A	—	192	—
	E	RB	193	—
Crataeva religiosa	E	LF	194	—
Crataeva tapia	U	LF	219	—
Gynandropsis gynandra	A	LF	194	—
Gynandropsis pentaphylla	A	—	318	—
Caprifoliaceae				
Viburnum foetidum	A	—	192	—
	E	PL	193	—
	U	LF	267	—
Caricaceae				
Carica papaya	A	FR, LX, SD	193	—
	A	—	192	—
	E	FR, LX, SD	193	—
	I	—	297–309	5-Hydroxytryptamine
Caryophyllaceae				
Lychnis miqueliana	U	—	201	—
Silene gallica var. *quinquevulnesea*	U	—	201	—
Casuarinaceae				
Casuarina equisetifolia	A	BK	195	—
Celastraceae				
Celastrus paniculatus	A	BK, LF	193	—
	A	—	192	—
	E	LF	91, 193	—
Euonymus cannabinum	A	—	192	—
Maytenus senegalensis	A	LF, RT	220	—
Chenopodiaceae				
Beta vulgaris	A	—	192	—
	E	SD, RT, LF	193	—
	E	LF, RT	194	—
Chenopodium ambrosioides	A	PL	194	—
	A	—	192	—
	E	PL	193	—
	E	LF	194, 197	—
Chenopodium vulvaria	E	LF	194	—
Mabrina ambrosioides	See *Chenopodium ambrosioides*			
Salicornia brachiata	E	AH	193	—
Salsola arbuscula	I	—	319	Salsoline (XVII)
Chloranthaceae				
Chloranthus serratus	U	—	201	—
Cochlospermaceae				
Cochlospermum insigne	U	SB	219	—
Cochlospermum tinctorium	E	RT, ST	193	—
Cochlospermum vitifolium	U	SB	219	—
Combretaceae				
Combretum gueinzii	A	RT	194	—
Terminalia bellerica	U	FR	320	—
Terminalia catappa	U	LS	294	—
Terminalia chebula	U	—	321	—
Terminalia ivorensis	I	—	322	Ellagic acid (CXXXIII)
Commelinaceae				
Aneilema conspicuum	A	—	192	—
	E	PL	193	—
Aneilema lineolatum	A	PL	193	See also *Murdannia elata*

Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
Murdannia elata	A	PL	193	—
Compositae				
Achillea millefolium	A	—	192	—
	E	FL, PL, LJ	193	—
	E	FL, LF	193	—
Anthemis nobilis	A	—	192	—
	E	VO	193	—
	E	PL	197	—
Anthemis tinctoria	E	FL, LF	197	—
Arctium lappa	U	—	201	—
Arnica sp.	U	—	324	—
Artemisia sp.	H	—	325	—
Artemisia abrotanum	E	LF, FL, SD	197	—
Artemisia absinthium	E	LF, FL	197	—
	H	—	326	—
Artemisia pontica	E	LF, FL	197	—
Artemisia siversiana	A	—	192	—
	E	PL	193	—
Artemisia vulgaris	A	PL	193	—
	A	—	192	—
	E	PL, LF, FL	193	—
	E	PL	323	—
	E	LF, RT, FL	197	—
	U	—	265	—
Atractylis lanatus	See *Carthamus lanatus*			
Atractylodes lancea	U	—	201	—
Baccharis articulata	U	—	327	—
Balsamita major	See *Tanacetum balsamita*			
Balsamita suaveolens	See *Tanacetum balsamita*			
Balsamita vulgaris	See *Tanacetum balsamita*			
Bidens pilosa	A	—	318	—
Blumea balsamifera	A	—	192	—
	E	LF	193	—
Blumea eriantha	A	—	192	—
	E	PL	193	—
Blumea lacera	A	—	192	—
	E	PL	193	—
Calcitrapa stellata	See *Centaurea calcitrapa*			
Calendula arvensis	A	—	192	—
	E	FL	193	—
	E	LF, FL	197	—
Calendula officinalis	A	—	192	—
	E	PL	197	—
	E	FL	193, 323	—
Carduus marianus	See *Silybum marianum*			
Carduus stellatus	See *Centaurea calcitrapa*			
Carthamus lanatus	E	LF, FL	197	—
Carthamus maculatus	See *Silybum marianum*			
Carthamus tinctorius	A	—	192	—
	E	FL	193	—
Centaurea calcitrapa	E	RT, FL	197	—
Centaurea centaurium	E	RT	197	—
Centaurea cyanus	A	—	192	—
	E	FL	193	—
Centaurium majus	See *Centaurea centaurium*			
Centipeda orbicularis	A	—	192	—
Chamaemelum tinctorium	See *Anthemis tinctoria*			
Chamomilla nobilis	See *Anthemis nobilis*			
Chrysanthemum indicum	A	—	192	—
	E	FL	193	—
Chrysanthemum leucanthemum	E	PL	197	—
Chrysanthemum parthenium	E	PL	197	—
Chrysanthemum sinense	E	PL	194	—
	I	—	328	Stachydrine (CXIV)
Chrysanthemum tanacetum	See *Tanacetum vulgare*			
Chrysanthemum vulgare	See *Tanacetum vulgare*			
Cichorium intybus	A	—	192	—
	E	PL	193	—
	E	SD	194	—
	E	RT	323	—
Conyza squarrosa	See *Inula conyza*			
Conyza vulgaris	See *Inula conyza*			
Costus hortensis	See *Tanacetum balsamita*			
Cota tinctoria	See *Anthemis tinctoria*			

(*continued*)

Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
Cotula sp.	A	—	192	—
	E	—	193	—
Dichrocephala chrysanthemifolia	A	PL	194	—
Doronicum pardalianches	E	RZ	197	—
Echinops echinatus	A	RT	193	—
Eriocoma floribunda	U	—	329	—
Ethulia conyzoides	A	RT	222	—
Eupatorium cannabinum	A	—	192	—
	E	PL	193	—
	E	FL, RZ, LF	197	—
Eupatorium odoratum	A	—	192	—
Gazania pinnata	E	LF, FL	194	—
Glossocarida bosvallea	A	—	192	—
	E	PL	193	—
Glossocardia linearifolia	See *Glossocardia bosvallea*			
Grangea maderaspatana	A	—	192	—
	E	RT, LF	193	—
	U	FR	330	—
	U	LF	267	—
Gutierrezia microcephala	U	—	200	Crude saponin mixture
Helianthus annuus	A	—	192	—
	E	FL	193	—
Hentrophyllum lanatum	See *Carthamus lanatum*			
Inula conyza	E	LF	197	—
Inula graveolens	E	PL	194	—
Inula squarrosa	See *Inula conyza*			
Leucanthemum parthenium	See *Chrysanthemum parthenium*			
Leucanthemum vulgare	See *Chrysanthemum leucanthemum*			
Leuzea carthamoides	U	—	331	—
Matricaria chamomilla	E	PL	197	—
Matricaria parthenium	See *Chrysanthemum parthenium*			
Melanthera scandens	A	LF	194	—
Microglossa pyrifolia	A	PL	194, 233	—
Montanoa tomentosa	A	—	90, 332	—
	E	—	332	—
Ormenis nobilis	See *Anthemis nobilis*			
Petasites sp.	I	—	333	Platyphylline (LXVIII)
	I	—	333	Senecionine (LXX)
Petasites officinalis	E	RZ, LF, FL	197	—
Porophyllum lencospermum	E	RT	334	—
Pyrethrum indicum	A	RT	193	—
	A	—	192	—
Pyrethrum parthenium	See *Chrysanthemum parthenium*			
Pyrethrum tanacetum	See *Tanacetum balsamita*			
Pyrethrum umbelliferum	A	—	192	—
	A	PL	193	—
Pyrethrum vulgare	See *Tanacetum vulgare*			
Santolina chamaecyparissus	E	LF, FL, SD	197	—
Santolina incana	See *Santolina chamaecyparissus*			
Saussurea lappa	A	—	192	—
	E	RT	91, 193	—
Senecio sp.	I	—	501–503	Cytisine (XLII)
	I	—	333	Integerrimine (LXVI)
	I	—	333	Longilobine (LXX)
	I	—	333	Platyphylline (LXVIII)
	I	—	333, 335	Pterophine[e]
	I	—	333	Retrornecine (LXXIII)
	I	—	333	Riddelliine (LXIX)
	I	—	333	Senecionine (LXX)
	I	—	333	Seneciphylline (jacobine) (LXXI)
	I	—	333	Spartioidine (LXXII)
Senecio sceleratus	I	—	333	Isatidine (LXVII)
	I	—	333	Sceleratine (LXV)
Senecio spartioides	I	—	333	Spartioidine
Senecio vulgaris	E	PL	194, 197	—
	I	—	333	Jacobine (seneciphylline)
	I	—	333	Platyphylline
	I	—	336	Senecine[e]
	I	—	333	Senecionine
	I	—	333	Seneciphylline (jacobine)
Siegesbeckia orientalis	A	—	192	—
	E	PL	193	—
Silybum marianum	E	RT, SD	197	—
	I	—	212, 217, 312	Tyramine
Sonchus asper	A	—	318	—

Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
Sphaeranthus sp.	A	PL	194	—
Sphaeranthus indicus	A	—	192	—
	E	PL	193	—
	U	—	337	—
Spilanthes acmella	A	—	318	—
Spina alba-hortensis	See *Silybum marianum*			
Tagetes minuta	E	LF	194	—
Tanacetum sp.	A	—	192	—
Tanacetum balsamita	E	LF, FL	197	—
Tanacetum vulgare	E	—	338	—
	E	PL	193	—
	E	FL, LF	197	—
	U	VO	339[d]	—
Tithonia diversifolia	U	LS	294	—
Tussilago farfara	A	RT, LF	193	—
	A	—	192	—
Tussilago hybrida	See *Petasites officinalis*			
Tussilago petasites	See *Petasites officinalis*			
Vernonia corymbosa	A	BU	194	—
	E	BU	194	—
Convolvulaceae				
Convolvulus bidentatus	A	PL	194	—
Convolvulus ulosepalus	A	PL	194	—
Cuscuta chinensis	A	—	204	—
Cuscuta reflexa	A	—	192	—
	A	ST, SD	193	—
	E	SD	193	—
Exogonium purga	E	TR	340	—
Ipomoea violacea	U	SD	341	Alkaloid fraction (ergonovine) (XCIII)
Operculina macrocarpa	U	TU	219	—
Rivea corymbosa	U	SD	341	Alkaloid fraction (ergonovine)
Coriariaceae				
Coriaria japonica	I	—	322	Ellagic acid
Crassulaceae				
Crassula sp.	A	RT	194	—
Cruciferae				
Anastatica hierochuntica	A	—	192	—
	A	PL	193	—
Brassica alba	A	—	192	—
Brassica cernua	U	—	201	—
Brassica juncea	E	—	193	—
Brassica nigra	A	—	192	—
Capsella bursa-pastoris	A	PL	192	—
	A	—	194	—
	E	PL	90, 194	—
	E	RT	197	—
	U	—	342	—
	I	—	212, 217, 312	Tyramine
Cheiranthus cheiri	A	—	192	—
	E	FL	193	—
Lepidium sativum	A	—	192	—
	A	SD	91, 193, 194	—
Matthiola incana	A	—	192	—
	E	LF	193	—
Matthiola tristis	A	—	192	—
	E	LF	193	—
Matthiola varia	E	LF	193	—
Nasturtium fontanum	See *Nasturtium officinale*			
Nasturtium officinale	A	—	192	—
	A	PL	90, 194	—
	E	PL	90, 194, 197	—
Raphanus sativus	A	—	192	—
	E	SD, LF	323	—
	E	SD	193, 194	—
Sisymbrium cardamime	See *Nasturtium officinale*			
Sisymbrium nasturtium	See *Nasturtium officinale*			
Cucurbitaceae				
Citrullus colocynthis	A	—	192	—
	A	RT	193	—
	E	RT	194	—
Cucumis trigonus	A	RT	193	—
	A	—	192	—
Cucurbita foetidissima	U	—	343	—
Gymnopetalum cochinchinensis	A	PL	193	—
	A	—	192	—
Luffa acutangula	A	—	192	—
Luffa acutangula var. *amara*	A	RB	193	—
Luffa cylindrica	U	LS	294	—

(*continued*)

Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
Luffa echinata	A	RB	193	—
	A	—	192	—
Luffa operculata	U	FR	219	—
Momordica balsamina	A	RT, FR, SD	194	—
Momordica cabrei	U	FR, BR, RT	344	—
Momordica charantia	A	PL, RT, JU	193	—
	A	—	192	—
	A	RT	194	—
	E	PL, RT, JU	193	—
Momordica cymbalaria	See *Momordica tuberosa*			
Momordica foetida	A	—	318	—
Momordica tuberosa	A	TR	193	—
	A	—	192	—
Trichosanthes bracteata	A	FR	193	—
Trichosanthes cucumerina	A	LS	193	—
	A	—	192	—
	E	LS	193	—
Trichosanthes palmata	See *Trichosanthes bracteata*			
Wilbrandia sp.	U	—	219	—
Cupressaceae				
Juniperus sp.	U	VO	345	—
Juniperus communis	A	VO	193	—
	A	—	192	—
	E	ST, VO, FR	193	—
Juniperus sabina	E	LF	197	—
	U	—	346	—
	U	VO	347–349, 919	—
	H	—	350–353	—
Thuja occidentalis	A	—	354	—
	U	—	355, 356	—
	H	—	355	—
Cyperaceae				
Carex brevicollis	I	—	357–361	Brevicolline (LXXIX)
	I	—	362, 398	Harman
Cyperus canescens	A	—	192	—
Cyperus longus	A	—	192	—
	E	TU	193	—
Cyperus rotundus	A	—	192	—
	A	TU	193	—
	A	TU	194	—
	E	RT, TU	194	—
Cyperus scariosus	E	RT	192, 193	—
Dipsacaceae				
Scabiosa succisa	E	RZ, PX	197	—
Succisa pratensis	See *Scabiosa succisa*			
Succisa scabiosa	See *Scabiosa succisa*			
Dipterocarpaceae				
Vateria indica	A	—	192	—
Ebenaceae				
Diospyros tricolor	U	—	363	—
	I	—	363	Uncharacterized quinone[e]
Ephedraceae				
Ephedra vulgaris	U	—	364	—
	I	—	364–380	Ephedrine
	I	—	381	Pseudoephedrine (VIII)
Ericaceae				
Ledum palustre var. *nipponicum*	U	—	201	—
Erythroxylaceae				
Erythroxylum coca	A	—	192	—
	E	LF	193	—
	I	LF	382–396	Cocaine (XIII)
	I	LF	317, 798–800	Nicotine
Lyonia ovalifolia var. *elliptila*	I	—	397	Lyoniol A (lyoniatoxin) (CXL)
Euphorbiaceae				
Acalypha indica	A	—	192	—
	E	—	193	—
Acalypha petiolaris	A	RT	194	—
Antidesma ghaesaembilla	A	—	192	—
	E	WD	193	—
Croton linearis	U	LS	225	—
Croton tiglium	A	RT, SO	193	—
	A	—	192	—
Euphorbia atoto	A	JU	193	—

Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
	A	—	192	—
Euphorbia lathyris	I	—	398	Aesculetin (CXXXIV)
Euphorbia pilulifera	U	—	399	—
Euphorbia resinifera	A	PL	193	—
	A	—	192	—
Euphorbia restituta	A	—	194	—
Euphorbia tirucalli	A	JU	193	—
	A	—	192	—
Excoecaria agallocha	A	LX	193	—
	A	—	192	—
Jatropha glandulifera	A	—	192	—
	E	LF	193	—
Jatropha multifida	A	—	192	—
	E	SO	193	—
Mildbraedia fallax	E	PL	194	—
Phyllanthus urinaria	A	—	192	—
	A	PL	193, 194	—
	E	PL	194	—
Ricinus communis	A	—	192	—
	E	LF, SO, SD	193	—
	E	LF	194	—
	U	LS	294	—
	I	—	400	Ricin[e]
	H	SO	401–409	Castor oil
Tragia involucrata	A	—	204	—
Gentianaceae				
Gentiana kurroa	A	—	192	—
	E	PL	193	—
Geraniaceae				
Erodium sp.	I	—	212, 217, 312	Tyramine
Erodium cicutarium	A	PL	194	—
	U	—	410	—
Pelargonium fumarioides	A	PL	194	—
Pelargonium reniforme	E	PL	194	—
Sarcocaulon sp.	A	PL	194	—
Gramineae				
Andropogon iwarancusa	A	—	192	—
Andropogon monticola	A	—	192	—
Andropogon muricatus	A	—	192	See also *Vetiveria zizanioides*
Andropogon schoenanthus	E	PL	194	—
Andropogon sorghum	I	—	211, 310	Hordenine
Arundo donax	A	—	192	—
	E	RZ	193, 197, 411	—
	I	—	412, 413	Gramine (= donaxine) (LXXVI)
Bambusa arundinacea	E	LF	193	—
Bambusa bambos	A	—	192	—
Brachiaria purpurascens	U	—	414	—
Coix lacryma-jobi var. *frumentacea*	I	—	415	Palmitic acid (CLIV)
Cymbopogon citratus	U	—	201	—
Cymbopogon iwarancusa	A	—	192	—
	E	PL	193	—
Cymbopogon nardus	E	PL	194	—
Dendrocalamus strictus	A	LF	193	—
	A	—	192	—
Eleusine indica	A	LF, JU	194	—
Eriocoma floribunda	A	PL	416	—
	U	—	416	—
Lolium temulentum	E	FR	197	—
	U	—	201	—
Panicum sp.	I	—	211, 310	Hordenine
Panicum maximum	U	LS	294	—
Vetiveria zizanioides	E	RT, RZ	193	—
Guttiferae				
Garcinia morella	A	—	192	—
	A	GU, RE	193	—
Hypericum perforatum	A	—	192	—
	E	PL	193, 323	—
	U	LF	267	—
Mesua ferrea	A	—	192	—
	E	PL	193	—
Ochrocarpus longifolius	A	—	192	—
Halorrhagidaceae				
Gunnera perpensa	A	RT	194	—
Iridaceae				
Crocus sativus	A	—	192	—
	E	—	323, 417	—

(*continued*)

Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
	E	SG, SL	193	—
	H	—	418	—
	U	—	419	—
Iris foetidissima	E	RZ	197	—
Iris germanica	U	RT	420	—
Iris sisyrinchium	U	SD	421	—
Spatula foetida	See *Iris foetidissima*			
Labiatae				
Ajuga genevensis	I	—	422	—
Ballota foetida	See *Ballota nigra*			
Ballota nigra	E	LF, FL	197	—
Calaminta clinopodium	See *Clinopodium vulgare*			
Cataria vulgaris	See *Nepeta cataria*			
Clinopodium vulgare	E	LF, FL	197	—
Coleus sp.	A	LF	194	—
Coleus barbatus	E	PL	194	—
Coleus kilimandscharica	A	LF	194, 423	—
Fuerstia africana	E	PL	194	—
Hedemoa pulegioides	E	LF, FL.	424	—
	U	VO	425[d]	—
Hyptis pectinata	A	—	192	—
	E	PL	193	—
Hyssopus officinalis	A	—	192	—
	E	LF, PL	193	—
	E	LF	197, 323	—
Hyssopus vulgaris	See *Hyssopus officinalis*			
Iboza riparia	U	—	201	—
Lagochilus sp.	U	—	426	—
Lagochilus inebrians	I	—	328	Stachydrine (CXIV)
Lamium sp.	I	—	212, 217, 312	Tyramine
Lamium album	E	PL	197	—
Lavandula stoechas	A	—	192	—
	E	PL	193	—
Leonotis nepetaefolia	A	—	192	—
	E	PL	193	—
Leonurus cardiaca	U	—	427	K ions (?)
	I	—	428	Leonurine[e]
	I	—	328	Stachydrine
Leonurus rubiastrum	U	—	427	K ions
Leonurus sibiricus	I	LF	429	Uncharacterized alkaloid
	I	—	428	Leonurine[e]
Leucas cephalotes	A	—	192	—
	E	PL	193	—
Leucas stelligera	A	—	192	—
	E	PL	193	—
Marrubium nigrum	See *Ballota nigra*			
Marrubium vulgare	A	—	192	—
	E	PL	197	—
	U	—	430	—
Melissa graveolens	See *Melissa officinalis*			
Melissa officinalis	E	LF, FL	197	—
Mentha arvensis	A	—	192	—
	E	PL	193	—
Mentha piperita	E	LF, FL	197	—
Mentha pulegium	A	VO	194	—
	E	VO	194	—
Nepeta cataria	A	—	318	—
	E	LF, FL	192, 193, 197	—
Nepeta vulgaris	See *Nepeta cataria*			
Ocimum basilicum	A	—	204	—
	E	PL	192, 193	—
Ocimum sanctum	A	—	204	—
Origanum amaracus	E	—	197	—
Origanum dictamnus	E	LF, FL	197	—
Origanum vulgare	A	—	192	—
	E	PL	193	—
Orthosiphon pallidus	U	—	431	—
Rosmarinus officinalis	A	—	192	—
	A	FL	194	—
Salvia sp.	E	LF	323	—
Salvia officinalis	A	—	192	—
	E	LF	193	—
Salvia plebeia	A	SD	193	—
	A	—	192	—
Salvia sclarea	E	LF, FL	194	—
Stachys aquatica	See *Stachys palustris*			
Stachys betonicaefolia	U	—	432, 433	—
Stachys lanata	U	—	434	—
	I	—	328	Stachydrine
Stachys palustris	A	—	192	—

Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
	E	PL	193	—
	E	LF, FL	194	—
	I	—	328	Stachydrine
Stachys sylvatica	A	—	192	—
	E	PL	193	—
	U	—	435	—
	I	—	328	Stachydrine
Teucrium polium	U	—	436	—
Thymus durius	See *Thymus vulgaris*			
Thymus serpyllum	A	PL	194	—
	A	—	192	—
	E	PL	193	—
Thymus vulgaris	E	PL	194, 197	—
Ziziphora tenuior	A	—	192	—
	E	PL	193	—
Lauraceae				
Cinnamomum camphora	A	PL	194	—
	A	—	192	—
	E	—	193	—
	I	—	437	Camphor (CXXXVII)
Cinnamomum cassia	A	BK	193	—
	A	—	192	—
	E	BK	193	—
Cinnamomum tamala	A	—	192	—
Cinnamomum zeylanicum	E	VO	193	—
Laurus nobilis	A	—	192	—
	E	FR, LF	193	—
Persea sp.	I	—	212, 217, 312	Tyramine
Persea americana	E	FP	194	—
	I	—	297-309	5-Hydroxytryptamine
Persea gratissima	E	LF	197	—
	I	—	297-309	5-Hydroxytryptamine
Lecythidaceae				
Combretodendron africanum	U	—	438	—
Leguminosae				
Abrus precatorius	A	SD	193	—
	A	—	192	—
	E	SD	91	—
Acacia sp.	A	WD	194	—
	I	—	211, 310	Hordenine
	I	—	317, 798-800	Nicotine
	I	—	212, 217, 312	Tyramine
Acacia nilotica	E	LF	194	—
Acacia rugata	A	—	192	—
Aeschynomene leptophylla	A	LF	233	—
Albizia sp.	I	—	439	Albitocin[e]
Albizia adianthifolia	U	RT	440	Saponin glycoside (?)
Albizia chinensis	A	PL	194	—
	U	—	441	—
	U	BK	440	Saponin glycoside (?)
Albizia grandibracteata	U	—	441	—
	U	BK	440	Saponin glycoside (?)
Albizia gummifera	U	—	441	—
	U	BK	440	Saponin glycoside (?)
	I	—	442, 443	Albitocin[e]
Albizia lebbeck	A	BK, SD	91	—
Anagyris foetida	E	FR	197	—
	I	—	250-252, 361, 385, 444-493	Sparteine (XL)
Astragalus hamosus	A	—	192	—
	E	PL	193	—
Bauhinia gapini	U	LS	294	—
Bauhinia retusa	A	—	192	—
	E	GU	193	—
Butea frondosa	See *Butea monosperma*			
Butea monosperma	A	—	192	—
	E	FL	193	—
Caesalpinia bonduc	E	FL	194	—
Caesalpinia crista	A	—	192	—
	E	LF, BK	193	—
Caesalpinia jayabo	A	—	192	—
	E	LF	193	—
Caesalpinia nuga	See *Caesalpinia crista*			
Caesalpinia pulcherrima	A	—	192	—
	A	LF, SD	194	—
	E	LF, BK, PL	193	—
Caesalpinia sappan	A	—	192	—

(*continued*)

Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
	E	WD	194	—
Caesalpinia sepiaria	A	—	192	—
Cassia absus	I	—	494–498	Chaksine (CXVII)
	I	—	499	Erysotrine (CXXIII)
Cassia didymobotrya	A	—	318	—
Cassia fistula	A	FR	91	—
Cassia lanceolata	A	—	192	—
	A	LF	193	—
Cassia occidentalis	U	LS	225	—
Cassia tora	I	SD	500	Uncharacterized principle
Cicer arietinum	A	—	192	—
	A	LF	193	—
Crotalaria incana	A	—	318	—
	I	—	333	Integerrimine (LXVI)
Crotalaria juncea	A	—	192	—
	A	LF	91	—
	E	LF	91	—
	E	SD	193	—
	I	—	333	Riddelliine (LXIX)
	I	—	333	Senecionine
Crotalaria spectabilis	I	—	333	Monocrotaline (LXIV)
Cytisus sp.	I	—	501–503	Cytisine (XLII)
	I	—	504	D-Lupanine (XXXVI)
	I	—	212, 217, 312	Tyramine
Cytisus laburnum	I	—	501–503	Cytisine
	I	—	250, 252, 361, 385, 444, 493	Sparteine
Cytisus scoparius	I	—	501–503	Cytisine
	I	—	250, 252, 361, 385, 444–493	Sparteine
	I	—	212, 217, 312	Tyramine
	H	—	250–252, 361, 385, 444–493	Sparteine
Dalbergia ferruginea	A	SW, RT	90	—
	E	SW, RT	90	—
	I	—	869	Coumingidine (CVI)
	I	—	869, 870	Coumingine (CVII)
Erythrophleum guineense	I	—	869	Cassaidine (CIV)
	I	—	869, 870	Cassaine (CV)
	I	—	869–872	Erythrophleine[e]
	I	—	869, 870	Homophleine[e]
	I	—	870	Norcassaidine (CVIII)
Genista sp.	I	—	501–503	Cytisine
	I	—	867, 868	Retamine (XXXIX)
	I	—	250, 252, 361, 385, 444–493	Sparteine
Genista tinctoria	U	FL	873	—
	I	FL	873	Sugar-like principle[e]
	I	—	501–503	Cytisine
	I	—	876, 878, 879	D-Lupanine (XXXVI)
Glycyrrhiza sp.	U	—	201	—
Glycyrrhiza glabra	A	—	192	—
	E	RT	193, 323	—
Indigofera linifolia	A	—	192	—
Indigofera suffruticosa	A	—	332	—
Lespedeza bicolor var. *japonica*	U	—	201	—
	I	—	874	*N,N*-Dimethyltryptamine (LXXIV)
	I	—	874	*N,N*-Dimethyltryptamine *N*-oxide (LXXV)
	I	—	874	5-Methoxy-*N,N*-dimethyltryptamine (LXXVIII)
Leucaena glauca	A	—	192	—
	E	RT, BK	194	—
Lupinus sp.	I	—	875	17-Hydroxylupanine (XXXV)
	I	—	875	Lupamine *N*-oxide (XXXVII)
	I	—	876	17-Oxolupanine (XXXVIII)
	I	—	504	Lupinine (XLIII)
	I	—	250, 252, 361, 385, 444–493	Sparteine
	I	—	504	Trilupine (XLI)
Lupinus albus	U	—	877	—
	I	—	875	17-Hydroxylupanine
	I	—	876, 878, 879	D-Lupanine (XXXVI)
	I	—	250, 252, 361, 385, 444–493	Sparteine
Lupinus perennis	I	—	875	13-Hydroxylupanine (XXXIV)
	I	—	875	17-Hydroxylupanine
Lupinus westianus	I	—	876, 878, 879	D-Lupanine

Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
	I	—	250, 252, 361, 385, 444, 493	Sparteine
Maackia amurensis	U	BK	880	—
	I	—	876, 878, 879	D-Lupanine
Medicago sativa var. *italica*	U	—	201	—
	I	—	328	Stachydrine
Mucuna cylindrosperma	I	—	881, 882	Physostigmine (XCII)
Mucuna pruriens	A	—	883	See also *Mucuna prurita*
	I	LF	883	*N,N*-Dimethyltryptamine
	I	LF	883	*N,N*-Dimethyltryptamine *N*-oxide
	I	LF	883	5-Hydroxytryptamine (LXXVII)
	I	LF	883	5-Methoxy-*N,N*-dimethyltryptamine (LXXVIII)
	I	—	317, 798–800	Nicotine
Mucuna prurita	A	—	192, 883	—
	E	RT	193	—
Physostigma venenosum	I	—	881, 882	Physostigmine
	I	SD	881, 882	Physostigmine
Pisum sativum	U	SD	884	—
	I	—	212, 217, 312	Tyramine
Pithecellobium multiflorum	U	GA, SB	219	—
Poinciana pulcherrima	A	—	192	—
Rhynchosia minima	A	—	192	—
	A	LF	193	—
Saraca indica	A	—	192	—
	E	BK	193	—
	I	—	885, 886	Phenolic glycoside
Sarcococca saligna	I	—	499	Erysotrine
Sesbania aegyptiaca	A	—	192	See also *Sesbania sesban*
	E	SD	91	—
Sesbania sesban	E	SD	193	—
Smirnovia turkestana	I	—	505	Sphaerophysine
	I	—	501–503	Cytisine
	I	—	250, 252, 361, 385, 444–493	Pachycarpine (sparteine)
Spartium junceum	U	—	869	—
	I	—	501–503	Cytisine
Sphaerophysa salsula	I	—	505	Sphaerophysine
Sutherlandia microphylla	E	LF	194	—
Swartzia madagascariensis	A	SP	194	—
Tamarindus indica	A	—	192	—
Tephrosia lupinifolia	A	RT	194, 920	Rotenone
Tephrosia piscatoria	I	—	504	Rotenone
Trachylobium hornemannianum	A	—	192	—
	E	GU	193	—
Trigonella foenum-graecum	A	—	192	—
	E	PL, SD	193	—
	E	SD	91	—
	U	SD	201, 507	—
Uraria lagopoides	A	PL	193	—
	A	—	192	—
	U	—	508	—
Liliaceae				
Agapanthus africanus	A	RT	194	—
Aletris farinosa	U	RZ, RT	509	—
Allium cepa	A	—	192	—
	E	BU, JU	193	—
	U	—	510	—
Allium fistulosum	U	—	201	—
Allium kurrat	U	LF	511	—
Allium sativum	A	—	192	—
	E	BU	193	—
	U	BU	510, 512, 513	—
Allium schoenoprasum	A	—	192	—
	E	BU	193	—
Aloe sp.	H	—	514	—
Aloe barbadensis	A	—	192	—
	E	PL	193	—
Aloe capensis	U	—	515	—
Aloe ferox	A	LF	194	—
Aloe littoralis	E	PL	193	—
Aloe perryi	A	—	192	—
Aloe vera	See *Aloe barbadensis*			
Asparagus acutifolia	E	—	90	—
Asparagus officinalis	A	—	192	—
	E	FR, PL	90	—

(*continued*)

Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
	E	FR	194	—
Asparagus striatus	A	TU	194	—
Asphodelus sp.	U	—	516	—
Chlorophytum comosum	A	TU	194	—
Colchicum sp.	I	—	517, 518	Colchicine (CXVIII)
Dipcadi glaucum	A	PL, BU	194	—
Eriospermum latifolium	E	TU	194	—
Fritillaria roylei	I	—	519	Peimine (verticine) (C)
	I	—	519	Fritillarine (CII)
	I	—	520, 521	Fritimine[e]
Gloriosa superba	A	—	192	—
	A	RS	194, 204	—
	A	TU	91, 193	—
	E	TU	91, 193	—
Lilium candidum	E	BU, PL	197	—
Lomatophyllum reflexum	E	FL	90	—
Ornithogalum eckloni	A	PL	194	—
Urginea indica	A	—	192	—
	E	BU	193	—
Veratrum sp.	I	—	522–524	Veratrine (CI)
Linaceae				
Linum usitatissimum	A	—	192	—
	E	—	193	—
Loganiaceae				
Gelsemium sempervirens	I	—	525–527	Gelsemicine (XCVI)
	I	—	528	Gelsemine (XCVII)
Strychnos sp.	I	—	529–547	*d*-Tubocurarine (XXXIII)
	I	—	548	Macusine B (LXXXIV)
Strychnos aculeata	A	PU	549	—
Strychnos nux-vomica	A	—	192	—
	E	SD	91	—
	E	FR	193	—
	I	—	550	Brucine (XCVIII)
	I	—	551–558	Strychnine (XCIX)
Strychnos toxifera	I	—	548	Macusine B
Loranthaceae				
Oryctanthus occidentalis	U	LS	225	—
Phoradendron sp.	I	—	312	Tyramine
Phoradendron rubrum	U	LS	225	—
Viscum album	I	—	559	"Cardiac principle"
	I	—	312	Tyramine
Viscum capense	E	ST	194	—
Lycopodiaceae				
Lycopodium sp.	I	—	560	Complanatine (CXI)
	I	—	560	*Lycopodium* alkaloid L-9 (lycofawcine) (CXIII)
	I	—	560, 561	Lycopodine (CIX)
	I	—	560	Obscurine (CXII)
Lycopodium annotinum	I	—	560, 561	Annotinine (CX)
	I	—	560, 561	Lycopodine
	I	—	317, 798–800	Nicotine
	I	—	560	Obscurine
Lycopodium selago	E	PL	197	—
	I	—	560, 561	Lycopodine
Lythraceae				
Lawsonia alba	See *Lawsonia inermis*			
Lawsonia inermis	A	—	192	—
	A	RT	193	—
	E	BK, FR	193	—
Woodfordia floribunda	A	PL	194	—
	E	PL	194	—
Magnoliaceae				
Michelia champaca	A	—	192	—
	E	RT, RB	193	—
	E	RT, FL	91	—
Malpighiaceae				
Byrsonima crassifolia	A	BK, FL, FR	90	—
Byrsonima sericea	U	SB	219	—
Malvaceae				
Abelmoschus manihot	E	BK	193	—
Abutilon indicum	A	—	318	—
	A	PL	194	—
Abutilon zanzibaricum	A	—	318	—
Gossypium sp.	U	LS	225	—
Gossypium arboreum	A	—	204	—
Gossypium barbadense	A	—	562	—
	E	—	562	—
Gossypium herbaceum	A	—	192	—
	A	PL	194, 562	—
	A	RB, SD	193	—

Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
	A	RB	91	—
	E	—	562	—
	E	RB	193, 197	—
	E	PL	194	—
Gossypium hirsutum	A	—	192	—
	E	RT	193, 562	—
	E	—	562	—
	I	—	297–309	5-Hydroxytryptamine
Hibiscus manihot	A	—	192	See also *Abelmoschus manihot*
Hibiscus rosa-sinensis	A	—	192	—
	E	FL	91, 193	—
Malva moschata	U	—	201	—
Urena lobata	A	RT	193	—
	A	—	192	—
Melastomataceae				
Memecylon amplexicaule	A	RT	193	—
Meliaceae				
Azadirachta indica	E	LJ, FL	193	—
Cedrela toona	A	—	192	—
	E	FL	193	—
Melia azadirachta	A	—	192	See also *Azadirachta indica*
Melia azedarach	A	—	192	—
Trichilia emetica	A	—	192	—
	E	BK	193	—
Walsura piscidia	A	—	192	—
	E	BK	193	—
Menispermaceae				
Anamirta cocculus	I	—	563–566	Picrotoxin (CXXXIX)
Arcangelisia flava	A	PL	567	—
	I	—	224–280	Berberine
	I	—	284	Columbamine
	I	—	280–281	Palmatine
	I	—	273	Jatrorrhizine
Chondodendron sp.	I	—	529–547	*d*-Tubocurarine
Cissampelos mucronata	A	RT	96	—
Cissampelos pareira	A	—	192	—
	E	RT	193, 194	—
Jateorhiza columba	I	—	273	Jatrorrhizine
	I	—	280, 281, 597, 599	Palmatine
Menispermum dauricum	I	—	568	Dauricine (XXXII)
	I	—	569–574	Parasinomenine[e]
	I	—	575–582	Sinomenine (LXII)
Pycnarrhena manilliensis	A	—	195	—
Tinospora bakis	E	RT	196	—
	I	—	280, 281, 597, 599	Palmatine
	I	—	274–280	Berberine
Molluginaceae				
Mollugo pentaphylla	A	—	192	—
Moraceae				
Antiaris toxicaria	U	JU	583, 584	—
Cecropia carbonaria	U	LF	219	—
Ficus sycomorus	A	—	318	—
Moringaceae				
Moringa oleifera	A	—	192	—
	A	RT, SB	193	—
	E	RT, SB	193	—
Moringa pterygosperma	A	RB	193, 194	See also *Moringa oleifera*
	I	—	583	Uncharacterized alkaloid
Myristicaceae				
Myristica fragrans	A	—	192	—
	A	PL	193	—
Myrsinaceae				
Embelia robusta	A	—	204	—
Embelia tsjeriam-cottam	See *Embelia robusta*			
Myrtaceae				
Myrtus communis	A	—	192	—
	E	FR	193	—
Nyctaginaceae				
Boerhaavia coccinea	U	RT	219	—
Olacaceae				
Liriosma ovata	U	BK	585	—
Oleaceae				
Jasminum multifida	A	SD	193	—
Jasminum multiflorum	E	RT	193	—
Jasminum officinale	A	—	192	—

(*continued*)

Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
Jasminum officinale var. *grandiflorum*	E	PL	193	—
Jasminum pubescens	See *Jasminum multiflorum*			
Jasminum sambac	A	—	192	—
	E	RT	193	—
Olea cuspidata	A	—	192	—
	E	FR	193	—
Phyllyrea latifolia	See *Phyllyrea media*			
Phyllyrea media	E	LF	197	—
Orchidaceae				
Dendrobium sp.	I	—	586	Dendrobine (CXX)
Oxalidaceae				
Oxalis acetosella	E	PL	194	—
Paeoniaceae				
Paeonia emodi	U	TU	587	—
Paeonia officinalis	E	RT	197	—
Palmae				
Areca catechu	A	—	192	—
	E	SD	193	—
	U	SD	588, 589	Tannin (?)
	I	—	590, 591	Arecoline (XI)
Cocos nucifera	A	—	192	—
Pandanaceae				
Pandanus odoratissimus	U	RT	592	—
Pandanus tectorius	A	RT	192	—
Papaveraceae				
Adlumia fungosa	I	—	593, 594	Adlumine (XIX)
	I	—	593	Bicuculline (XX)
Argemone mexicana	A	RT	195	—
	E	SO	194	—
	U	RS	595	Total alkaloids
	U	—	201	—
	I	—	274–280	Berberine
	I	—	596–598	Chelerythrine (XLIV)
	I	—	201, 597, 599	Protopine (LVIII)
Chelidonium majus	U	—	201	—
	I	—	274, 280	Berberine
	I	—	596–598	Chelerythrine
	I	—	597, 918	Chelidonine (XLV)
	I	—	201, 597, 599	Protopine (LVIII)
	I	—	250–252, 361, 385, 444–493	Sparteine
	I	—	312	Tyramine
Corydalis sp.	A	—	192	—
	E	RT	193	—
	I	—	274–280	Berberine
	I	—	593	Bicuculline
	I	—	600	Corlumine (XXII)
	I	—	597	Capauridine [(±)-capaurine] (XLVI)
	I	—	597	Capnoidine (XXI)
	I	—	601	Cularine (CXXI)
	I	—	597	Ochotensine (CXXII)
	I	—	597	Ophiocarpine (L)
	I	—	280, 281, 597, 599	Palmatine
Corydalis ambigua	I	—	602	*Corydalis alkaloid* B (tetrahydropalmatine) (LI)
	I	—	597	Adlumine
	I	—	602	*Corydalis* alkaloid J[e]
	I	—	602	*Corydalis* alkaloid L[e]
	I	—	602	*Corydalis* alkaloid M[e]
	I	—	280, 281, 597, 599	Palmatine
	I	—	597	Tetrahydropalmatine
	I	—	597	Adlumidine (XVIII)
Corydalis incisa	I	—	280, 281, 597, 599	Protopine
	I	—	597	Tetrahydropalmatine
Corydalis ochotensis	I	—	603–605	Cryptocavine (cryptopine) (LVI)
	I	—	597	Ochotensine
	I	—	201, 597, 599	Protopine
Corydalis tuberosa	I	—	597	Canadine (CXXV)
	I	—	597	Corydaline (XLVIII) (*Corydalis* alkaloid A)
	I	—	597	Tetrahydropalmatine
Fumaria micrantha	U	—	848	—
Glaucium flavum	U	—	606	—
	I	—	596, 598	Chelerythrine

Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
	I	—	597, 918	Chelidonine (XLV)
	I	—	201, 597, 599	Protopine
Glaucium rubrum	U	—	606	—
Hunnemannia fumariaefolia	I	—	274–280	Berberine
	I	—	596–598	Chelerythrine
	I	—	603	Hunnemannine (LVII)
Macleaya cordata	U	—	201	—
	I	—	596, 598	Chelerythrine
	I	—	201, 597, 599	Protopine
Papaver sp.	I	—	607, 849	Narcotine (XXIV)
	I	—	607, 849, 851, 852, 864, 865	Thebaine (LXIII)
Papaver somniferum	I	—	607, 865	Codeine (LX)
	I	—	608, 848–863	Morphine (LXI)
	I	—	609, 850, 852, 866	Papaverine (XVI)
Sanguinaria canadensis	A	—	603	—
	U	RT	603	Total alkaloids
	I	—	274–280	Berberine
	I	—	596–598	Chelerythrine
	I	—	201, 597, 599	Protopine
Passifloraceae				
Passiflora foetida	A	—	192	—
	E	LF	193	—
	I	—	297–309	5-Hydroxytryptamine
	U	—	610	—
Passiflora incarnata	U	—	828	Harman (LXXXI)
	U	—	823–826	Harmaline (LXXX)
Pedaliaceae				
Dicerocaryum zanguebaricum	A	LF, JU	194	—
Pedalium murex	A	FL	194	—
	A	—	192	—
	E	FJ, LF	193	—
	E	PL	194	—
Sesamum indicum	A	SD, OL	194	—
	A	SD	193	—
	A	—	192	—
	E	SD	193	—
	E	SD, OL	194	—
Phytolaccaceae				
Petiveria alliaceae	U	LS	294	—
Phytolacca americana	U	—	201	—
Phytolacca decandra	A	RT	611	—
	A	LF, SH	194	—
Pinaceae				
Pinus longifolia	A	—	192	See also *Pinus roxburghii*
Pinus ponderosa	U	LF	612	—
Pinus roxburghii	E	GU	193	—
Piperaceae				
Piper aurantiacum	A	FR	193	—
	A	—	192	—
	U	—	613	—
Piper auritum	U	LS	225	—
Piper betle	A	—	204	—
Piper longum	A	FR	91, 193	—
	A	—	192	—
	E	FR	91, 193	—
Piper nigrum	A	—	192	—
	A	FR	91, 193, 194	—
Plantaginaceae				
Plantago sp.	A	—	318	—
Plumbaginaceae				
Plumbago capensis	U	LS	294	—
Plumbago europaea	I	—	614, 615	Plumbagin (CXXXVI)
Plumbago indica	A	RT	193	—
Plumbago rosea	A	—	193	See also *Plumbago indica*
	U	RT	192, 616	—
Plumbago viscosa	See *Plumbago zeylanica*			
Plumbago zeylanica	A	RT	193	—
	A	PL	194, 195	—
	A	—	192	—
	I	—	614, 615	Plumbagin
Polygalaceae				
Polygala amara	E	RT	197	—
Polygala amarella	See *Polygala amara*			
Polygala senega	U	—	201	—
Polygala teretifolia	A	PL	194	—
Polygala uliginosa	See *Polygala amara*			
Securidaca longepedunculata	A	RB	194	—

(*continued*)

Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
Polygonaceae				
Antigonon leptopus	U	LS	294	—
Fagopyrum cymosum	U	—	201	Rutin (CXLVII)
Polygonum aviculare	H	—	616	—
Polygonum bistorta	U	—	201	—
Polygonum hydropiper	A	PL	323	—
	A	—	192	—
	E	PL, LF	193	—
Polygonum senegalense	A	LF	233	—
Rheum emodi	A	—	192	—
	E	RT	193	—
Triplaris gardenriana	U	SB	219	—
Polypodiaceae				
Adiantum capillus-veneris	A	—	192	—
	E	PL	193	—
Adiantum pedatum	A	—	192	—
	E	PL	193	—
Adiantum venustum	A	—	192	—
	E	FD	193	—
Asplenium adiantum-nigrum	A	—	192	—
	E	FD	193	—
Dryopteris filix-mas	A	RT	90	—
	A	—	192	—
Pteridium aquilinum	E	RT	194	—
Portulacaceae				
Portulaca oleracea	U	LS	225	—
Talinum cunefolium	A	—	318	—
Primulaceae				
Androsale septentrionalis	A	PL	616	—
Cyclamen europaeum	E	TU	197	—
Cyclamen persicum	A	—	192	—
	E	—	193	—
Punicaceae				
Punica granatum	A	RB	194	—
	A	—	193	—
	E	RB	194	—
	U	FP	616	—
Ranunculaceae				
Anemone obtusiloba	E	LF, BK	193	—
Clematis hirsuta	A	LF	617	—
Coptis japonica	U	—	618	Crude alkaloids
	I	—	274–280	Berberine
	I	—	284	Columbamine
	I	—	273	Jateorrhizine (= jatrorrhizine)
	I	—	280, 281, 597, 599	Palmatine
Helleborus niger	A	—	192	—
	A	RT	90	—
	E	RZ	193	—
Hydrastis canadensis	U	—	619	—
	I	—	274–280	Berberine
	I	—	597	Canadine
	I	—	620–627	Hydrastine (XXIII)
	I	—	628–633	Hydrastinine (XV)
Jateorhiza palmata	U	—	618	Alkaloid extract
	I	—	280, 281, 597, 599	Palmatine
Melanthium sativum	See *Nigella sativa*			
Nigella sativa	A	—	192	—
	A	SD	91	—
	E	SD	91, 193, 197	—
Pulsatilla sp.	U	—	634	—
Ranunculus sp.	I	—	297–309	5-Hydroxytryptamine
Ranunculus sceleratus	A	—	192	—
	E	PL	193	—
Thalictrum sp.	I	—	358, 361	Thalictrimine (β-allocryptopine) (LIX)
Thalictrum revolutum	U	—	635, 636	Tertiary alkaloids
Rhamnaceae				
Zizyphus abyssinica	A	RT	220	—
Zizyphus joazeiro	U	SB	219	—
Zizyphus mauritiana	U	LS	294	—
Zizyphus undulata	U	SB	219	—
Rosaceae				
Caryophyllata urbana	See *Geum urbanum*			
Caryophyllum officinalis	See *Geum urbanum*			
Geum caryophyllum	See *Geum urbanum*			
Geum urbanum	E	RZ	197	—
Hagenia abyssinica	A	—	192	—

Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
	A	PL	193	—
Prunus sp.	I	—	297–309	5-Hydroxytryptamine
	I	—	212–217	Tyramine
Prunus amygdalus var. *amara*	E	SD	194	—
Prunus amygdalus var. *dulcis*	E	SD	194	—
Prunus cerasus	E	SD	194	—
Prunus mahaleb	A	—	192	—
	E	FR	193	—
Prunus persica	A	—	192	—
	E	SD	193	—
Pyracantha angustifolia	U	—	201	—
Rubus moluccanus	A	—	192	See also *Rubus rugosus*
Rubus rigidus	A	RT	194	—
Rubus rugosus	A	LF	193	—
	E	LF	193	—
Rubiaceae				
Borreria verticillata	U	RT	219	—
	I	—	637	Emetine (CXXVIII)
Cephaelis ipecachuana	I	—	637	Emetine
Cinchona calisaya	A	—	192	—
	E	—	193	—
	I	—	638	Cinchonidine (XXVII)
	I	—	638, 639	Cinchonine (XXVIII)
	I	—	638, 640	Quinidine (XXX)
	I	—	641, 682	Quinine (XXXI)
	H	—	347, 402–404, 408, 409, 683–767	Quinine
Cinchona ledgeriana	I	—	682	Hydroquinine (XXIX)
Crossopteryx africana	See *Crossopteryx febrifuga*			
Crossopteryx febrifuga	A	BK	222	—
Crossopteryx kotschyana	See *Crossopteryx febrifuga*			
Diodia barbeyana	U	RT	219	—
Guettarda angelica	U	RB	219	—
Mitragyna inermis	I	—	768, 769	Mitrinermine (XCIV) (rhynchophylline)
Mitragyna stipulosa	I	—	768, 769	Mitrinermine (rhynchophylline)
Dalbergia sisso	A	BK, WD	193	—
	A	—	192	—
Delonix regia	U	SB	219	—
Derris chinensis	I	—	194, 920	Rotenone (CXLVIII)
Derris elliptica	I	—	194, 920	Rotenone
Desmodium retroflexum	A	—	192	—
	E	RT	193	—
Desmodium tiliaefolium	A	—	192	—
Dolichos biflorus	A	—	192	—
	E	SD	193	—
Dolichos lablab	A	—	192	—
	E	LF	193	—
Elephantorrhiza sp.	A	BK	194	—
Entada africana	A	BK	194	—
Entada phaseoloides	A	SD	194	—
Eremosparton flaccidum	I	—	505	Sphaerophysine (CXVI)
Erythrina indica	A	—	192	See also *Erythrina variegata* var. *occidentalis*
Erythrina suberosa	I	—	499	Erysotrine (CXXIII)
Erythrina variegata	A	—	192	—
Erythrina variegata var. *occidentalis*	E	LF	193	—
Erythrina velutina	U	SD	219	—
Erythrophleum coumingo	I	—	869	Coumingaine[e]
Morinda citrifolia	A	—	192	—
	E	FR	193	—
Oldenlandia affinis	U	PL	770	—
	I	—	771, 772	Two polypeptides[e]
Oldenlandia herbacea	A	PL	194	—
Paederia foetida	A	—	192	—
	E	PL	193	—
Pentas purpurea	E	RT	194	—
Pseudocinchona africana	I	—	773, 774	Corynanthine (LXXXVIII)
Randia dumetorum	A	—	192	—
	A	FP	193	—
Rondeletia africana	See *Crossopteryx febrifuga*			
Rondeletia febrifuga	See *Crossopteryx febrifuga*			
Rubia cordifolia	A	—	192	—
	A	PL	194	—
	E	RT	193, 194	—
Rubia major	See *Rubia tinctorum*			
Rubia tinctorum	A	—	192	—

(*continued*)

Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
	E	RT	193, 197	—
Tocoyena formosa	U	RB	219	—
Uncaria sp.	I	—	775	Mitrinermine (rhynchophylline)
Uncaria gambier	I	—	775	Gambirine (LXXXVII)
Rutaceae				
Citrus sp.	I	—	776	Hesperidin (CXLV)
	I	—	212–217	Tyramine
Clausena anisata	A	PL, LF	194	—
Dictamnus albus	A	—	192	—
	E	RT	197	—
	I	—	777	Dictamnine (XXV)
	I	—	778	Skimmianine (XXVI)
Dictamnus fraxinella	See *Dictamnus albus*			
Evodia hortensis f. *hortensis*	E	BJ	779	—
	I	—	274, 280	Berberine
Evodia inu-ankend	E	FL, LF	193	—
Evodia roxburghiana	See *Evodia inu-ankend*			
Evodia rutaecarpa	U	—	201	—
Lunasia amara	I	—	780	Lunamarine (CXXIV)
Pilocarpus jaborandi	I	LF	781, 786	Pilocarpine (CXXVI)
Ruta graveolens	A	—	192	—
	A	PL	90, 194, 323	—
	A	RT	91	—
	E	PL	90, 193, 194, 323	—
	E	RT	91	—
	E	LF	197	—
	U	—	787, 789, 790	—
	H	—	326	—
	I	—	778	Skimmianine
Ruta hortensis	U	PL	791	—
Ruta montana	A	LF	197	—
Ruta sylvestris-major	See *Ruta graveolens*			
Santalaceae				
Santalum album	A	—	192, 193	—
Thesium hystrix	A	RT	194	—
Sapindaceae				
Cardiospermum halicacabum	A	—	192	—
	A	PL	194	—
	E	RT, LF	193	—
	E	PL	194	—
Sapindus emarginatus	A	FR, SD	91, 193	—
	E	SD	193	—
Sapindus trifoliatus	A	FR	91	See also *Sapindus emarginatus*
	A	—	192	—
Schmidelia affinis	See *Rhus longipes*			
Sapotaceae				
Mimusops elengi	A	FR	195	—
Saxifragaceae				
Ribes americanum	E	RT	792	—
Scrophulariaceae				
Buchnera ciliata	A	PL	793	—
Celsis caucasica	A	—	192	—
Herpestis monnieri	I	—	794	Saponin glycoside
	I	—	317, 798–800	Nicotine
Pedicularis palustris	I	—	795	Uncharacterized glycoside
Picrorhiza kurroa	A	—	192	—
	A	RZ	193	—
	E	RZ	193	—
	E	RT	91	—
Scoparia dulcis	U	RT	219	—
Sutera atropurpurea	A	FL	194	—
	E	FL	194	—
Simaroubaceae				
Picrasma ailanthoides	U	—	201	—
Simarouba versicolor	U	RB	219	—
Solanaceae				
Capsicum frutescens	U	LS	294	—
Datura tatula	U	—	201	—
	I	—	796, 797	Scopolamine (XIV)
Lycium barbatum	A	—	192	—
	E	FR	193	—
Nicotiana tabacum	A	LF	194	—
	I	—	317, 798–800	Nicotine (X)
Physalis minima	A	PL	194	—
Solanum sp.	A	—	318	—
	I	—	212–217	Tyramine

Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
	I	—	297–309	5-Hydroxytryptamine
Solanum nigrum	A	—	192	—
	A	RB	193	—
Solanum paniculatum	U	LF, RT	801	—
	U	RT	219	—
Solanum variabile	U	—	801	—
Solanum verbascifolium	U	LS	294	—
Withania coagulans	A	—	192	—
	E	SD	193	—
Withania somnifera	A	—	192	—
	A	RT	193, 194	—
	I	—	317, 798–800	Nicotine
Stemonaceae				
Stemona sp.	I	—	802	Paipunine[e]
Stemona japonica	U	—	201	—
Sterculiaceae				
Abroma augusta	A	—	192	—
	A	BK	194	—
	E	RB	193	—
	E	RT, RB	194	—
	E	PL	803	—
	E	RT	91	—
	U	ST, RT	804, 805	—
Guazuma ulmifolia	U	SB	219	—
Helicteres isora	U	FR	267	—
Pentapetes phoenicea	A	—	204	—
Theobroma cacao	A	RT	195	—
Waltheria indica	A	PL	194	—
Styracaceae				
Styrax japonica	U	—	201	—
Taxaceae				
Taxus baccata	A	—	192	—
	A	LF	194	—
	E	LF	91, 197	—
	E	LF, FR	193, 194	—
	U	—	91, 791, 806	—
	H	—	807	—
	I	—	365, 380	Ephedrine (V)
Torreya nucifera	U	SD	808	—
Theophrastaceae				
Jacquinia pungens	A	—	332	—
Thymelaeaceae				
Arthrosolen polycephalus	A	PL	194	—
Daphne genkwa	U	—	201	—
Gnidia chrysantha	A	RT, FL	194	—
Lasiosiphon capitatus	A	PL	194	—
Lasiosiphon kraussianus	A	RT	220	—
Tiliaceae				
Grewia asiatica	A	—	192	—
Grewia barteri	U	—	809	—
	I	—	810	Amine-imidazole type of compound[e]
Grewia bicolor	U	—	809	—
Grewia carpinifolia	U	—	809	—
	I	—	810	Amine-imidazole type of compound[e]
Grewia cissoides	U	—	809	—
	I	—	810	Amine-imidazole type of compound[e]
Grewia cyclopetala	U	—	809, 811	—
Grewia elyseoi	U	—	809, 812	—
	I	—	810	Amine-imidazole type of compound[e]
Grewia hirsuta	A	—	192	—
	E	LF, FR	193	—
Grewia lasiodiscus	U	—	809	—
	I	—	810	Amine-imidazole type of compound[e]
Grewia malacocarpa	U	—	809	—
	I	—	810	Amine-imidazole type of compound[e]
Grewia occidentalis	A	PL	194	—
Grewia salvifolia	See *Grewia bicolor*			
Grewia venusta	U	—	809	—
	I	—	810	Amine-imidazole type of compound[e]
Grewia villosa	U	—	809	—
Triumfetta bartramia	A	—	192	—

(*continued*)

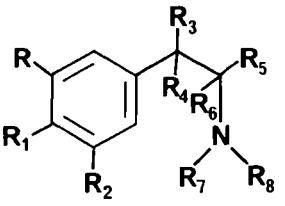
Table IV—(*Continued*)

Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
	A	RT	193	—
Triumfetta rhomboidea	A	RT	193, 194	See also *Triumfetta bartramia*
Turneraceae				
Turnera sp.	U	RT	219	—
Typhaceae				
Typha capensis	A	RT, PL	194	—
Ulmaceae				
Celtis australis	A	—	192	—
Umbelliferae				
Ammi visnaga	E	FR	197	—
	I	—	813	Khellin (visammin) (CXXXV)
Anethum foeniculum	See *Foeniculum officinale*			
Anethum graveolens	E	FR	193	—
Anethum sowa	A	—	192	—
Angelica archangelica	E	PL	323	—
Angelica sylvestris	E	RT	197	—
Apium graveolens	A	—	192	—
	A	RT, SD	193	—
	A	VO	194	—
	U	—	814	—
Athamanta cretensis	E	FR	176	—
Athamanta neumi	See *Meum athamanticum*			
Carum copticum	A	—	192	See also *Trachyspermum ammi*
	E	SD	193	—
Carum roxburghianum	A	—	192	—
	E	SD	193	—
Centella asiatica	E	PL	193	—
Chaerefolium silvestre	U	RT	814	—
Cuminum cyminum	A	FR	193	—
	A	—	192	—
	E	FR	193, 197	—
	I	—	506, 507	Coumingine (CVII)
Daucus carota	A	—	192	—
	A	SD, LF	194	—
	E	SD	193	—
	E	RT, SD	197	—
	E	RT	194	—
	U	—	814	—
Daucus creticus	See *Athamanta cretensis*			
Daucus visnaga	See *Ammi visnaga*			
Eryngium sp.	A	—	332	—
Ferula assa-foetida	A	—	192	—
Ferula caspica	U	—	815	—
Ferula foetida	E	GU, RE	193	—
Ferula nartex	E	GU	91	—
	E	ST, GU	193	—
Ferula orientalis	A	—	192	—
	E	GU, RE	193	—
Foeniculum capillaceum	See *Foeniculum officinale*			
Foeniculum officinale	E	FR, RT	197	—
Foeniculum sylvestre	See *Foeniculum officinale*			
Foeniculum vulgare	A	—	192	See also *Foeniculum officinale*
	E	SD, FR	193	—
	E	FR	194	—
Hydrocotyle asiatica	A	—	192	See also *Centella asiatica*
Imperatoria ostruthum	See *Peucedanum ostruthum*			
Imperatoria sylvestris	See *Angelica sylvestris*			
Meum athamanticum	E	RT, SD	197	—
Meum foeniculum	See *Foeniculum officinale*			
Petroselinum crispum	E	FR	194	—
Petroselinum hortense	A	—	192	—
	U	—	816	—
Petroselinum sativum	A	PL	194	—
	E	FR	194	—
	I	FR	817–822	Apiol (CXXIX)
	H	FR	823–844	Apiol
Peucedanum galbanum	A	PL	194	—
Peucedanum graveolens	A	—	192	See also *Anethum graveolens*
Peucedanum officinale	E	RT	197	—
Peucedanum ostruthum	E	RZ	197	—
Pimpinella saxifraga	E	RT	197	—
	U	—	814	—
Prangos pabularia	A	—	192	—
	E	FR, RT	193	—
Selinum sylvestre	See *Angelica sylvestris*			

Table IV—(*Continued*)

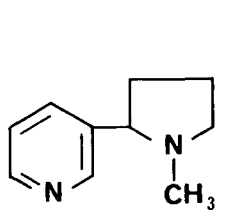
Plant Name[a]	Type of Activity[b]	Plant Part[c]	Reference	Active Constituent(s)
Steganotaenia araliacea	A	PL	194	—
Trachyspermum ammi	E	SD	193	—
Urticaceae				
Urtica sp.	I	—	270	Betaine
Urtica dioica	A	PL	194	—
	A	—	192	—
	E	PL	193	—
	I	—	297–309	5-Hydroxytryptamine
Urtica urens	A	PL	194	—
	I	—	297–309	5-Hydroxytryptamine
Valerianaceae				
Nardostachys jatamansai	A	—	192	—
	E	RT	193	—
Valeriana wallichii	A	—	192	—
	E	RT	193	—
Verbenaceae				
Clerodendrum inerme	U	LF	887	—
Clerodendrum serratum	A	—	204	—
Gmelina asiatica	A	RT	193	—
Stachytarpheta jamaicensis	A	—	192	—
	A	PL	193	—
Verbena bonaviensis	A	PL	194	—
Verbena officinalis	A	—	192	—
	I		888, 889	Verbenalin (verbenaloside) (CXLIX)
Verbena stricta	I		888, 889	Verbenalin (verbenaloside)
Vitex agnus-castus	E	FR	197	—
Vitex cannabifolia	U	—	201	—
Vitex gardneriana	U	SB	219	—
Vitex negundo	A	—	192	—
	E	FR	193	—
Vitex trifolia	A	—	192	—
	E	FR	193	—
Vitaceae				
Ampelopsis hederaceae	I	—	890–892	Catechol (CXXXI)
Cissus quadrangularis	A	—	192	—
Cissus sicyoides	U	LS	294	—
Rhoicissus cuneifolia	A	RT	194	—
Vitis quadrangularis	A	—	192	—
Vitis vinifera	E	FL	193	—
Zingiberaceae				
Alpinia speciosa	U	LF	219	—
Curcuma longa	A	—	192	—
	A	RZ, JU	194	—
	E	RZ	193	—
	U	—	201	—
Curcuma zedoaria	A	—	192	—
Elettaria cardamomum	A	—	192	—
	E	FR	193	—
Hedychium spicatum	A	—	192	—
	E	RT	193	—
Zingiber officinale	A	—	204	—
Zygophyllaceae				
Fagonia arabica	See *Fagonia cretica*			
Fagonia cretica	A	—	192	—
	E	PL	193	—
Peganum harmala	A	—	192	—
	A	PL, SD	193	—
	A	SD	91	—
	E	PL, SD	193	—
	E	—	91	—
	I	SD	893–896	Harmaline
	I	SD	893–897	Harmine (LXXXII)
Tribulus alatus	A	—	192	—
	E	FR	193	—
Tribulus terrestris	A	—	192	—
	E	RT	193	—
	I	—	898	Harman
	I	—	893–897	Harmine
Zygophyllum coccineum	U	—	899	—
Zygophyllum decumbens	U	—	900	—

[a] Plant names are as stated in the original articles except for corrections of obvious spelling errors. Arrangement is alphabetical by family, genus, and species; assignment to families is according to the system of Engler (1672). [b] A = abortifacient, ecbolic, oxytocic (folkloric); E = emmenagogue, affecting the menstrual cycle (folkloric); U = uterine stimulant as shown by *in vitro* or *in vivo* tests in animals; H = abortifacient effects as determined in humans; I = active substance isolated and shown to stimulate uterine tissue either *in vitro* or *in vivo*. [c] AH = ash, BA = balsam, BJ = bark juice, BR = branches, BK = bark, BU = bulb, EX = exudate, FL = flower, FP = fruit pulp, FR = fruit, FS = fruit shell, GU = gum, JU = juice, LF = leaf, LJ = leaf juice, LS = leaf and stem, LX = latex, OL = oil, PL = whole plant, PU = pulp, PX = aerial parts, RB = root bark, RE = resin, RS = root stalk, RT = root, RZ = rhizome, SB = stem bark, SD = seed, SG = stigma, SL = style, SO = seed oil, SP = seed pod, SW = stem wood, TE = tegumen, TR = tuberous root, TU = tuber, TW = twigs, VO = volatile oil, WD = wood, and — = plant part not stated in original article. [d] Although popularly believed to exert an oxytocic effect, the essential oil was shown to depress uterine tissue *in vitro* rather than cause a contraction. [e] Denotes that although the material was obtained as a crystalline or otherwise pure entity, the structure is not yet known.

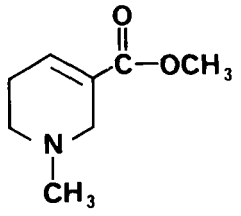


	R	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8
V: ephedrine	H	H	H	OH	H	CH_3	H	H	CH_3
VI: hordenine	H	OH	H	H	H	H	H	CH_3	CH_3
VII: mescaline	OCH_3	OCH_3	OCH_3	H	H	H	H	H	H
VIII: pseudoephedrine	H	H	H	H	OH	CH_3	H	H	CH_3
IX: tyramine	H	OH	H	H	H	H	H	H	H

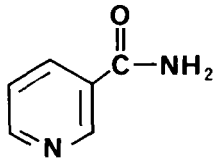
Structures of Phenethylamine Alkaloids Having Uterine Stimulant Activity



X: nicotine

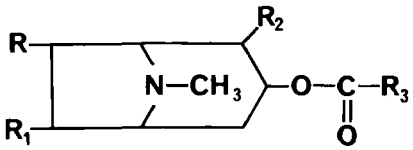


XI: arecoline



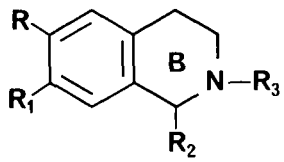
XII: nicotinamide

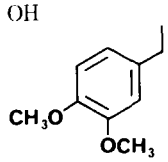
Structures of Pyridine Alkaloids Having Uterine Stimulant Activity



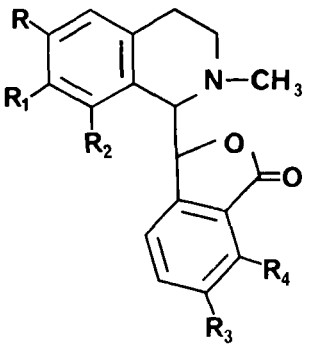
	R	R_1	R_2	R_3
XIII: cocaine	H	H	$COOCH_3$	phenyl
XIV: scopolamine	—O—		H_2	$-CH(CH_2OH)-$

Structures of Tropane Alkaloids Having Uterine Stimulant Activity



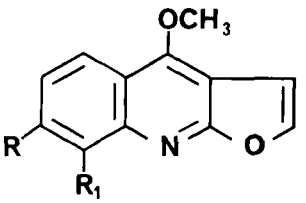
	R	R_1	R_2	R_3
XV: hydrastinine	—O—CH_2—O—		OH	CH_3
XVI: papaverine	OCH_3	OCH_3		ring B unsaturated
XVII: salsoline	OH	OCH_3	CH_3	H

Structures of Quinoline Alkaloids Having Uterine Stimulant Activity



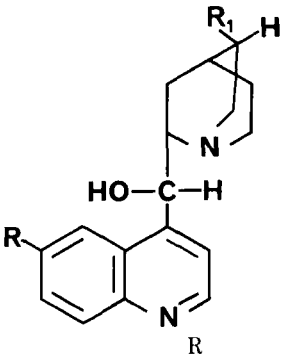
	R	R_1	R_2	R_3	R_4
XVIII: adlumidine	—O—CH_2—O—		H	—O—CH_2—O—	
XIX: adlumine	OCH_3	H	H	—O—CH_2—O—	
XX: bicuculline	—O—CH_2—O—		H	—O—CH_2—O—	
XXI: capnoidine	—O—CH_2—O—		H	—O—CH_2—O—	
XXII: corlumine	OCH_3	OCH_3	H	—O—CH_2—O—	
XXIII: hydrastine	—O—CH_2—O—		H	OCH_3	OCH_3
XXIV: narcotine	—O—CH_2—O—		OCH_3	OCH_3	OCH_3

Phthalidisoquinoline Alkaloid Structures Having Uterine Stimulant Activity



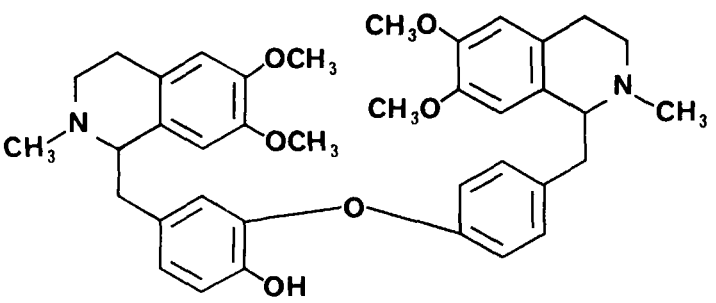
	R	R_1
XXV: dictamnine	H	H
XXVI: skimmianine	OCH_3	OCH_3

Structures of Furoquinoline Alkaloids Having Uterine Stimulant Activity

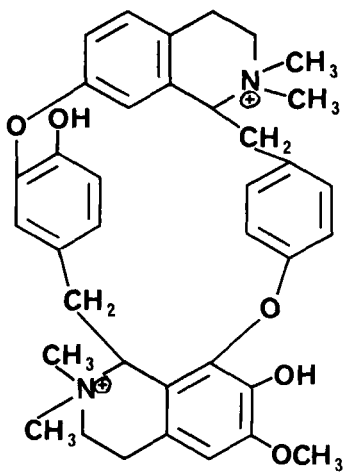


	R	R_1
XXVII: cinchonidine	H	$CH=CH_2$
XXVIII: cinchonine	H	$CH=CH_2$
XXIX: hydroquinine	OCH_3	$CH_2—CH_3$
XXX: quinidine	OCH_3	$CH=CH_2$
XXXI: quinine	OCH_3	$CH=CH_2$

Structures of Quinine Alkaloids Having Uterine Stimulant Activity

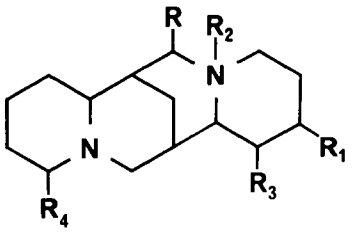


XXXII: dauricine

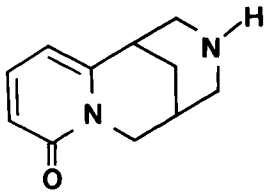


XXXIII: *d*-tubocurarine

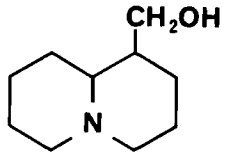
Structures of Bisbenzylisoquinoline Alkaloids Having Uterine Stimulant Activity



	R	R_1	R_2	R_3	R_4	other
XXXIV: 13-hydroxylupanine	H	OH	—	H	=O	—
XXXV: 17-hydroxylupanine	OH	H	—	H	=O	—
XXXVI: D-lupanine	H	H	—	H	=O	—
XXXVII: lupanine *N*-oxide	H	H	O	H	=O	—
XXXVIII: 17-oxolupanine	=O	H	—	H	=O	—
XXXIX: retamine	H	H	—	OH	=O	—
XL: sparteine	H	H	—	H	H	—
XLI: trilupine	H	H	—	H	=O	$\cdot HCl \cdot 2H_2O$

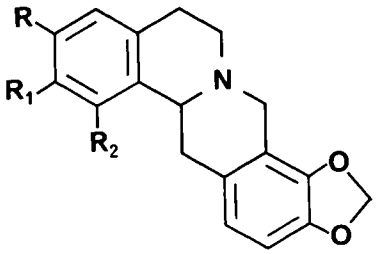


XLII: cytisine



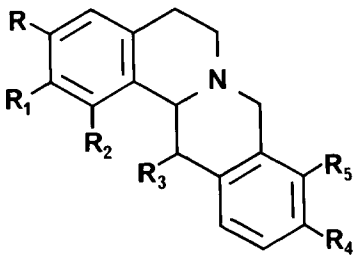
XLIII: lupinine

Structures of Quinolizidine Alkaloids Having Uterine Stimulant Activity



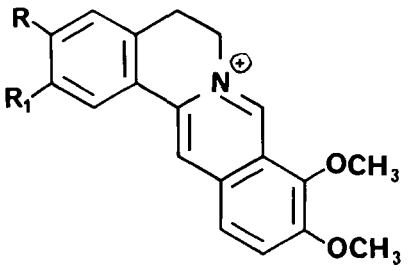
	R	R_1	R_2	other
XLIV: chelerythrine	OCH_3	OCH_3	H	unsaturated C ring
XLV: chelidonine	—O—CH_2—O—		OH	$\Delta^{1,2}$

Structures of Benzophenanthridine Alkaloids Having Uterine Stimulant Activity



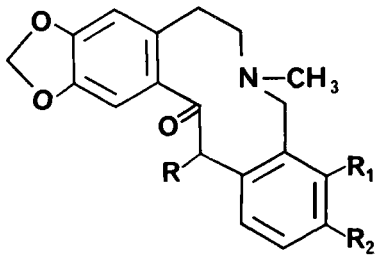
	R	R_1	R_2	R_3	R_4	R_5
XLVI: capauridine	OCH_3	OCH_3	OH	H	OCH_3	OCH_3
XLVII: capaurine	OCH_3	OCH_3	OH	H	OCH_3	OCH_3
XLVIII: corydaline	OCH_3	OCH_3	H	CH_3	OCH_3	OCH_3
XLIX: nandinine	—O—CH_2—O—		H	H	OCH_3	OH
L: ophiocarpine	—O—CH_2—O—		H	OH	OCH_3	OCH_3
LI: tetrahydropalmatine	OCH_3	OCH_3	H	H	OCH_3	OCH_3

Structures of Protoberberine Alkaloids Having Uterine Stimulant Activity



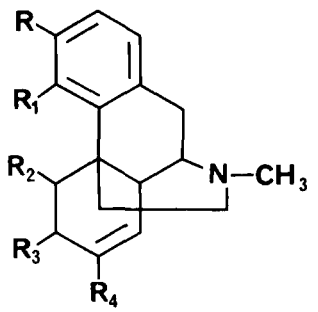
	R	R_1
LII: berberine	—O—CH_2—O—	
LIII: columbamine	OCH_3	OH
LIV: jatrorrhizine	OH	OCH_3
LV: palmatine	OCH_3	OCH_3

Structures of Protoberberine Alkaloids Having Uterine Stimulant Activity



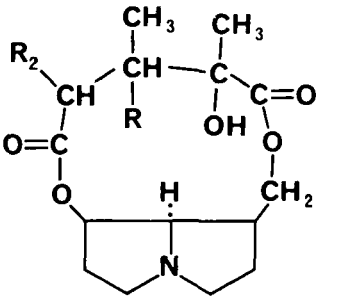
	R	R_1	R_2	other
LVI: cryptocavine	H	OCH_3	OCH_3	—
LVII: hunnemannine	CH_3	OCH_3	OCH_3	—
LVIII: protopine	H	—O—CH_2—O—		—
LIX: thalictimine	H	OCH_3	OCH_3	desoxy

Structures of Protopine Alkaloids Having Uterine Stimulant Activity



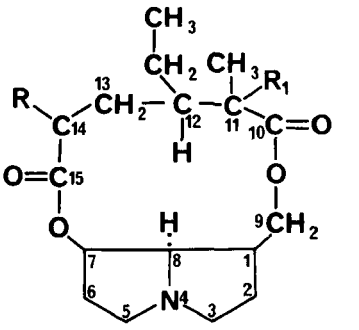
	R	R_1	R_2	R_3	R_4
LX: codeine	OCH_3	—O—		OH	H
LXI: morphine	OH	—O—		OH	H
LXII: sinomenine	OCH_3	OH	H	=O	OCH_3
LXIII: thebaine	OCH_3	—O—		OCH_3	H

Structures of Morphinan Alkaloids Having Uterine Stimulant Activity

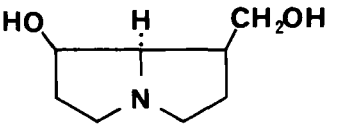


	R	R_1	R_2
LXIV: monocrotaline	OH	—CH_3	
LXV: sceleratine	H	—CH—$(CH_3)_2$	
		OH	

Structures of Pyrrolizidine Alkaloids Having Uterine Stimulant Activity

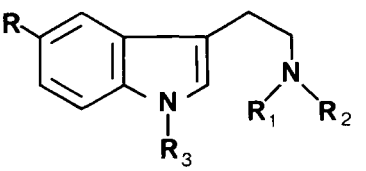


	R	R_1	other
LXVI: integerrimine	CH_3	OH	$\Delta^{1,2}$
LXVII: isatidine	CH_2OH	OH	—
LXVIII: platyphylline	CH_3	OH	—
LXIX: riddelliine	OH	CH_2OH	$\Delta^{12,13}$
LXX: senecionine	OH	CH_3	—
LXXI: seneciphylline	CH_3	OH	$\Delta^{12,13}$
LXXII: spartioidine	OH	CH_3	$\Delta^{12,13}$



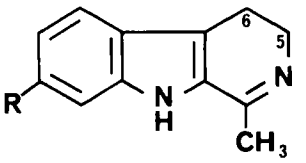
LXXIII: retrornecine

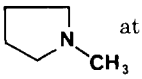
Structures of Pyrrolizidine Alkaloids Having Uterine Stimulant Activity



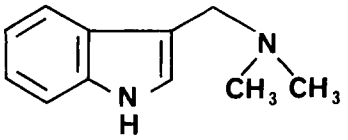
	R	R_1	R_2	R_3
LXXIV: *N,N*-dimethyltryptamine	H	CH_3	CH_3	H
LXXV: *N,N*-dimethyltryptamine *N*-oxide	H	CH_3	CH_3	H
LXXVII: 5-hydroxytryptamine	OH	H	H	O
LXXVIII: 5-methoxy-*N,N*-dimethyltryptamine	OCH_3	CH_3	CH_3	H

Structures of Tryptamine Alkaloids Having Uterine Stimulant Activity

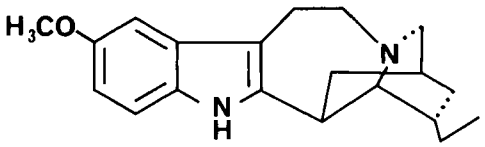


	R	other
LXXIX: brevicolline	H	 at 6-position
LXXX: harmaline	OCH_3	—
LXXXI: harman	H	—
LXXXII: harmine	OCH_3	$\Delta^{5,6}$

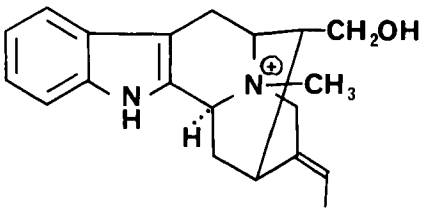
Structures of β-Carboline Alkaloids Having Uterine Stimulant Activity



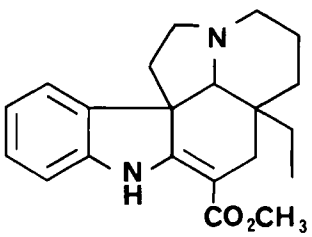
LXXVI: gramine



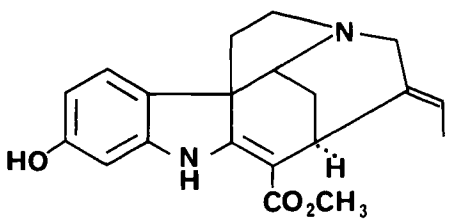
LXXXIII: ibogaine



LXXXIV: macusine B

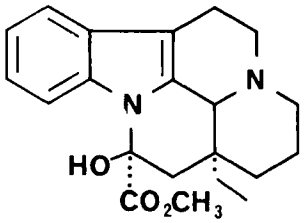


LXXXV: ervamine

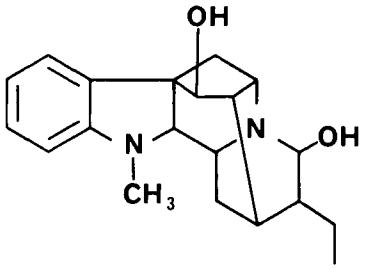


LXXXVI: vinervine

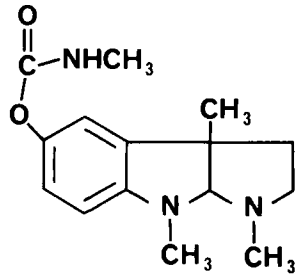
Structures of Miscellaneous Indole Alkaloids Having Uterine Stimulant Activity



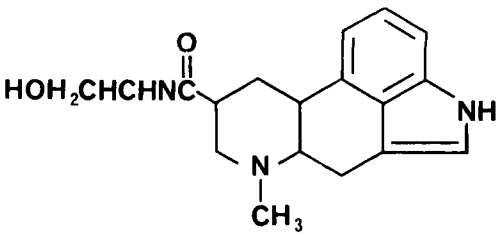
XC: vincamine



XCI: ajmaline



XCII: physostigmine



XCIII: ergonovine

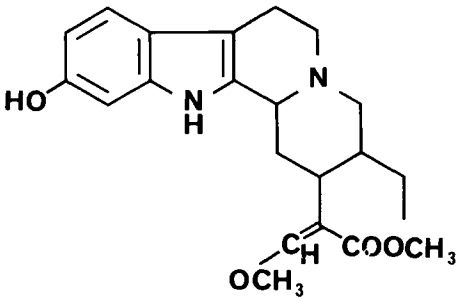
Structures of Miscellaneous Indole Alkaloids Having Uterine Stimulant Activity

During the literature search, some naturally occurring plant principles were found that were active as uterine stimulants, but the plants from which they were obtained were not noted. Whenever one of these active principles was known to occur in a plant previously noted under (A), (E), or (U), it was entered in Table IV as (I).

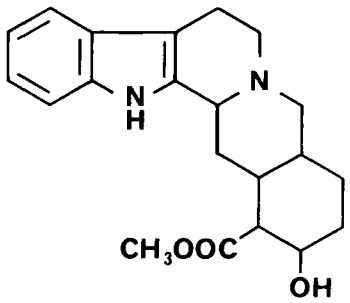
Finally, Table IV lists those plants and/or constituents that have been shown to be abortifacient or to have uterine stimulant activity as judged from tests in humans. These entries are noted as (H).

Although it is not within the scope of this presentation to give detailed information on all animal and human studies, a few remarks will be made concerning the abortifacient effects of some plant materials that have been used over the years as abortifacients.

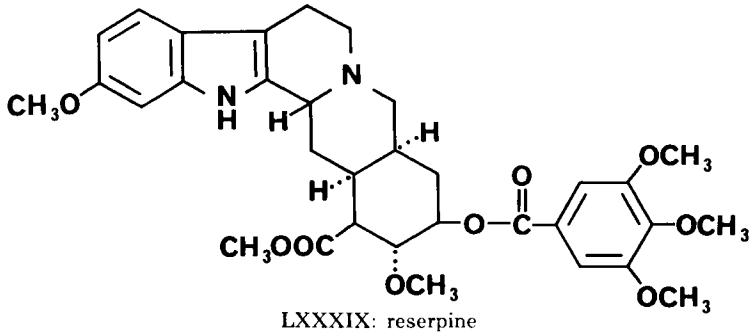
Volatile Oils—The most commonly employed volatile oils used in the past to induce abortion are those derived from *Tanacetum vulgare* (tansy), *Hedeoma pulegioides* (pennyroyal), *Ruta graveolens* (rue), *Petroselinum sativum* (apiol), and *Juniperus sabina* (savin). The literature contains virtually nothing with regard to the proven abortifacient effects of these materials. In fact, the use of these materials for abortifacient effects has been deleted from most standard pharmacology textbooks published in the last two decades. It has been shown that the excised human uterus is not stimulated by the oils of pennyroyal, savin, or tansy (198). It is



LXXXVII: gambirine



LXXXVIII: corynanthine



LXXXIX: reserpine

Structures of Miscellaneous Indole Alkaloids Having Uterine Stimulant Activity

speculated that when abortion does occur after the use of these volatile oils, it occurs only following toxic doses (198); fatal doses are not always abortifacient.

An interesting situation exists with apiol. There are two forms of this drug, "green apiol," which is the oleoresin of *P. sativum*, and "apiol" proper or "crystallized apiol," a compound of known structure. Both of these materials have a long history as abortifacients, alone or in combination with such materials as ergot extract. Numerous toxicities to apiol following its use in attempted abortion, as evidenced by a polyneuritis, were reported in the 1930's (823–832, 840, 841). It was eventually found that the toxicities were due to the presence of *ortho*-tricresyl phosphate in the apiol, presumably present as an adulterant (842, 843). It is safe to conclude that these materials were never consistently effective as abortifacients in humans and that their use will always be attendent with varying degrees of toxicity and even death (844).

Quinine and Castor Oil—These two agents have been used extensively in the past, alone or in combination with pituitary extract, to induce abortion in humans. Quinine has been reported in many studies to contract uterine tissue in both *in vitro* and *in vivo* experiments (641–682). Clinical studies are also numerous (347, 402–404, 408, 409, 683–767). It has been concluded (767) that except in cases of idiosyncrasy, quinine does not act to expel the premature fetus. There is no doubt, however, that quinine does help to promote uterine contractions after they have begun. The contractions produced by quinine in these cases are intermittent and not tetanic.

Although studies involving the use of castor oil in human abortion are numerous (401–409), one cannot find experimental studies to explain the rationale for its use. Presumably, it produces pelvic congestion as a result of intestinal irritation, as with the volatile oils (198).

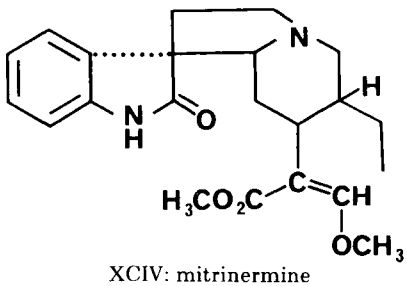
Sparteine—The only clinically useful abortifacient plant product known at present is sparteine (pachycarpine), which is an alkaloid derived from several Leguminosae species, especially those in the genera *Ammodendron, Baptisia, Cytisus, Genista, Goebelia, Lupinus, Retama, Sarothamnus, Templetonia,* and *Thermopsis* (845–847). Reports of the occurrence of sparteine in the unexpected Papaveraceae *(Chelidonium majus)* and Scrophulariaceae *(Leptorhabdos parviflora)* species should be reexamined (845–847).

Sparteine was first introduced into clinical practice as an oxytocic in 1939, and thousands of patients have been treated with it (487–489). Numerous reports confirm its *in vitro* and *in vivo* uterine stimulant activity (250, 252, 361, 385, 444–493). It has virtually all of the oxytocic properties of oxytocin and the ergot alkaloids. Untoward effects in humans almost always relate to overstimulation of the myometrium; thus, the dose of this alkaloid must be closely monitored. The latest review on the clinical use of sparteine as an oxytocic was published in 1966 (489).

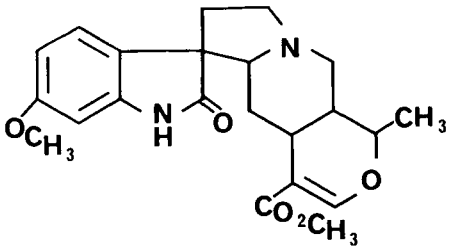
From the data presented in Tables IV and V, it can be seen that 565 species of plants are known to have a folkloric reputation for use as abortifacients, ecbolics, or emmenagogues. These 565 species are classified in 125 plant families. Of this 565 species, 225 have been shown to elicit a stimulant response when tested against uterine muscle either *in vitro* or *in vivo*, and active uterine stimulants have been isolated from 198 species. Of the isolated compounds, 148 are of known structure and 24 are of unknown structure; 122 of the isolated active compounds are alkaloids. Table V lists a number of common and widespread plant constituents that have been reported to stimulate uterine tissue either *in vivo* or *in vitro*.

Table V—Plant Principles of Widespread Occurrence Reported to Stimulate Uterine Tissue

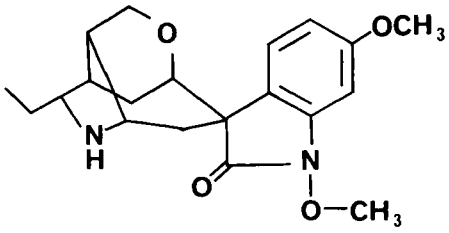
Plant Principle Type	Constituent	Reference
Simple amines	Betaine (CXV)	270
	Hordenine (VI)	310
	5-Hydroxytryptamine (LXXVII)	297–309
	Tyramine (IX)	312
Fatty acid	Arachidonic acid (CLI)	901, 902
	Linoleic acid (CLII)	901
	Linolenic acid (CLIII)	901
	Palmitic acid (CLIV)	415
Flavonoids	Hesperidin (CXLV)	776
	Quercetin (CXLVI)	903
	Rutin (CXLVII)	904
Sterols	Cholesterol (CXLI)	905
	β-Sitosterol (CXLII)	906
Polyphenols	Catechol (CXXXI)	820, 822
	Pyrogallol (CXXXII)	906
Miscellaneous	Ascorbic acid (CXXX)	907–911
	Ellagic acid (CXXXIII)	322
	Guaiazulene (CXXXVIII)	912
	Nicotinamide (XII)	913–915
	Tannin	916, 917



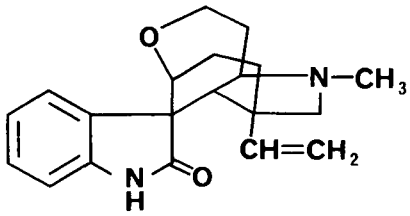
XCIV: mitrinermine



XCV: vineridine

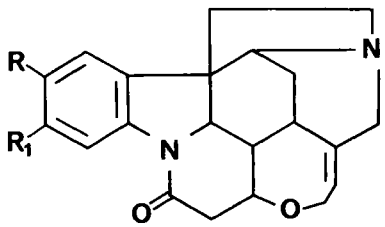


XCVI: gelsemicine



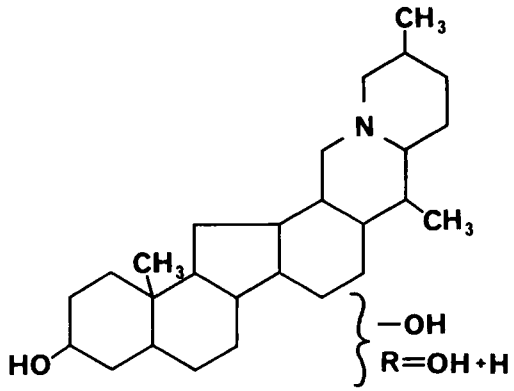
XCVII: gelsemine

Structures of Miscellaneous Indole Alkaloids Having Uterine Stimulant Activity

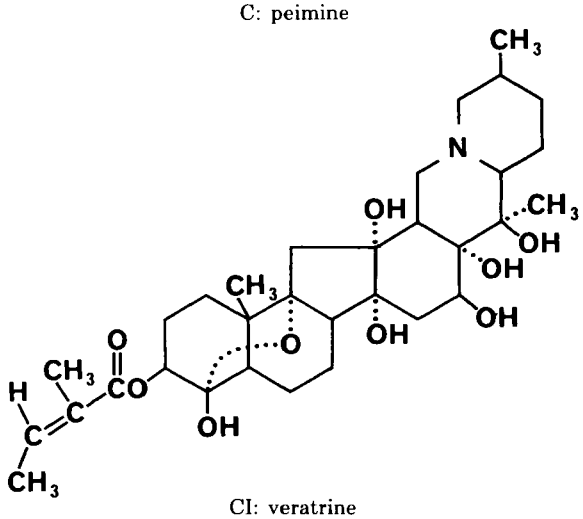


	R	R_1
XCVIII: brucine	OCH_3	OCH_3
XCIX: strychnine	H	H

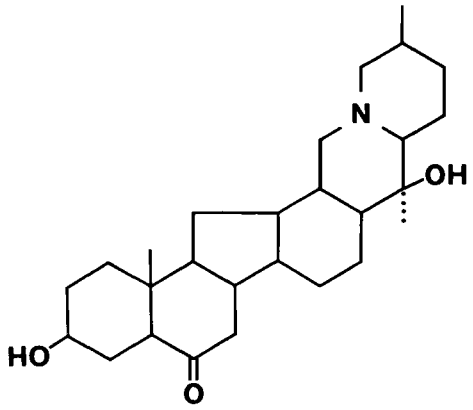
Structures of Miscellaneous Indole Alkaloids Having Uterine Stimulant Activity



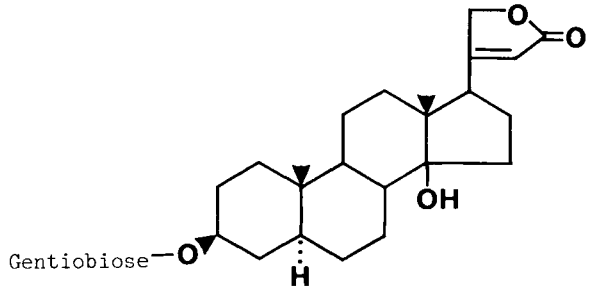
C: peimine



CI: veratrine

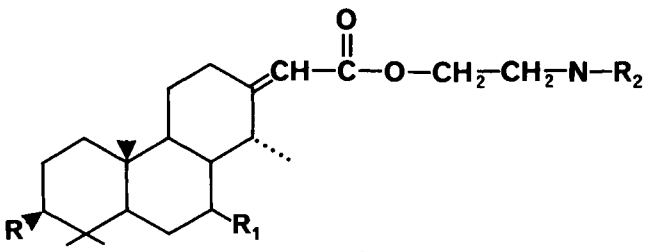


CII: fritillarine

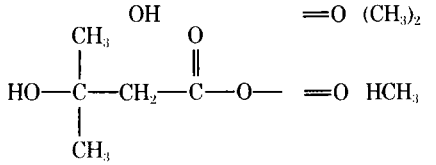


CIII: uzarine

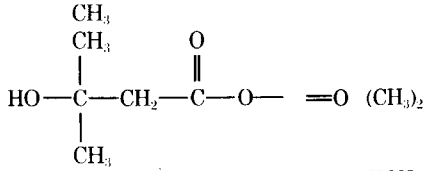
Structures of Steroid Alkaloids Having Uterine Stimulant Activity



	R	R_1	R_2
CIV: cassaidine	OH	α-OH	$(CH_3)_2$
CV: cassaine	OH	=O	$(CH_3)_2$



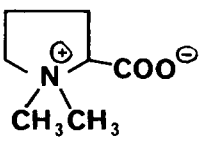
CVI: coumingidine =O HCH_3



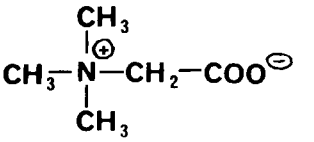
CVII: coumingine =O $(CH_3)_2$

CVIII: norcassaidine OH α-OH HCH_3

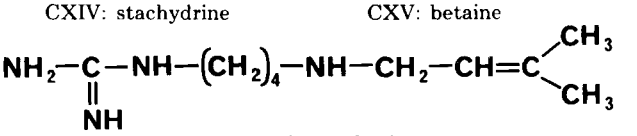
Structures of Diterpene Alkaloids Having Uterine Stimulant Activity



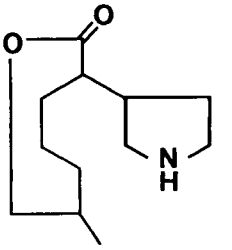
CXIV: stachydrine



CXV: betaine

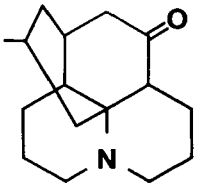


CXVI: sphaerophysine

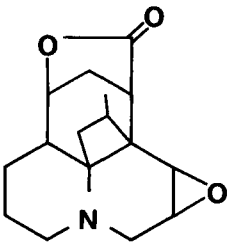


CXVII: chaksine

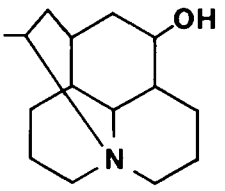
Structures of Miscellaneous Alkaloids Having Uterine Stimulant Activity



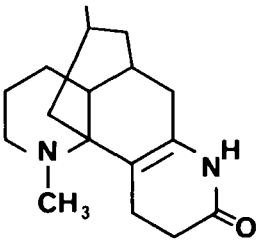
CIX: lycopodine



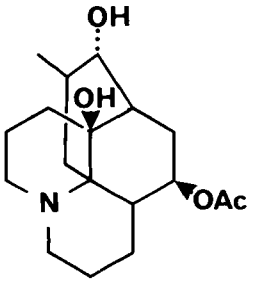
CX: annotinine



CXI: complanatine

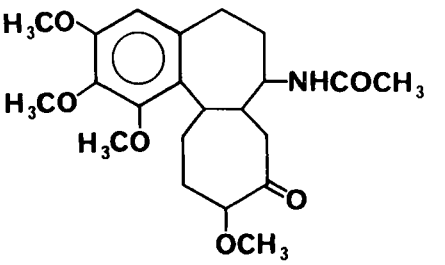


CXII: obscurine

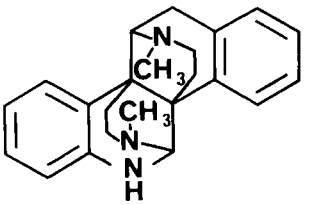


CXIII: lycofawcine

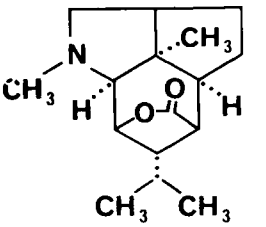
Structures of Hydrojulolidine and Related Alkaloids Having Uterine Stimulant Activity



CXVIII: colchicine

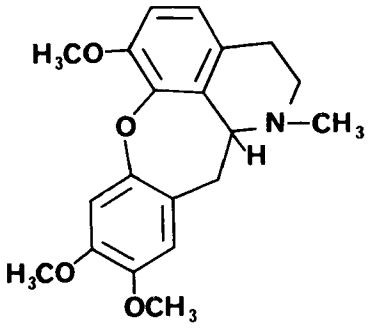


CXIX: calycanthine

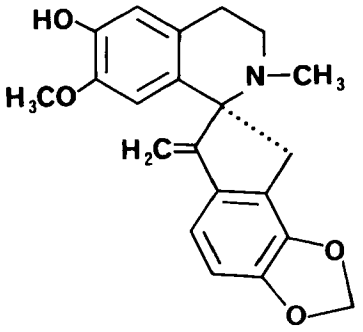


CXX: dendrobine

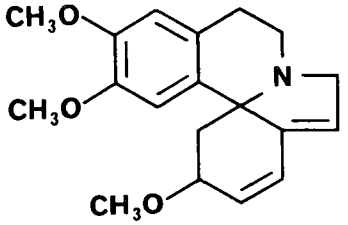
Structures of Miscellaneous Alkaloids Having Uterine Stimulant Activity



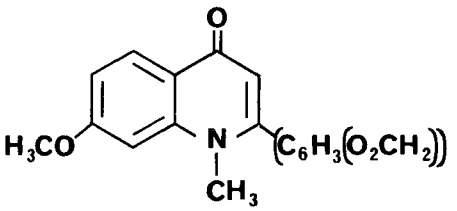
CXXI: cularine



CXXII: ochotensine

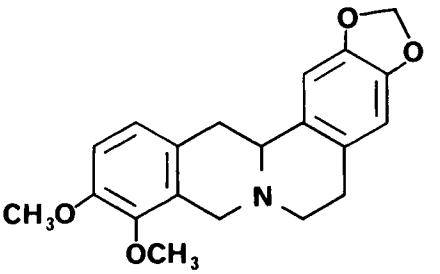


CXXIII: erysotrine

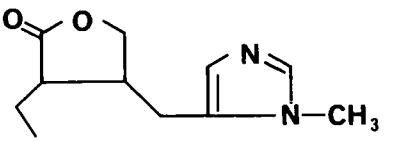


CXXIV: lunamarine

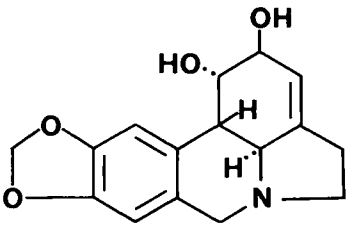
Structures of Miscellaneous Alkaloids Having Uterine Stimulant Activity



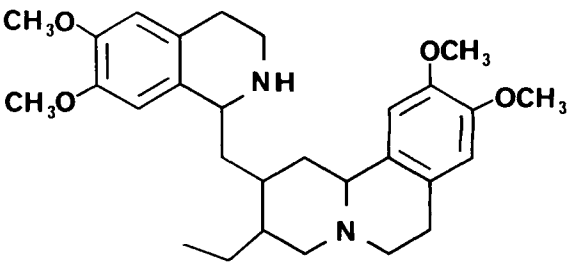
CXXV: canadine



CXXVI: pilocarpine

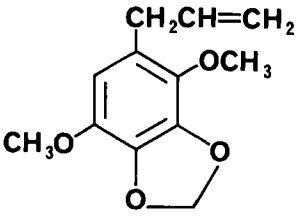


CXXVII: lycorine

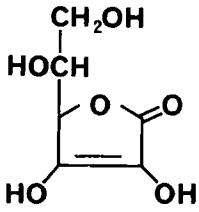


CXXVIII: emetine

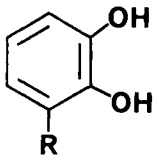
Structures of Miscellaneous Alkaloids Having Uterine Stimulant Activity



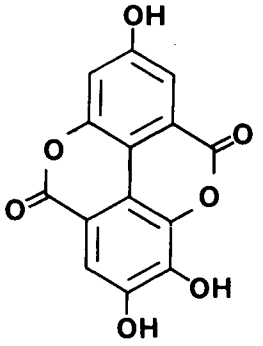
CXXIX: apiol



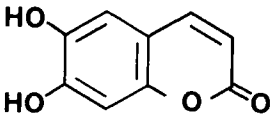
CXXX: ascorbic acid



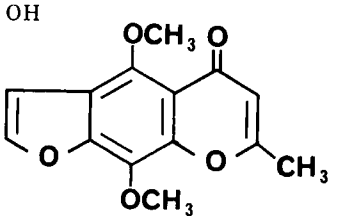
CXXXI: catechol, R = H
CXXXII: pyrogallol, R = OH



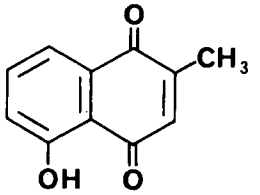
CXXXIII: ellagic acid



CXXXIV: aesculetin

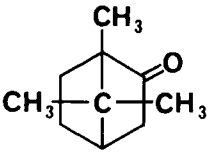


CXXXV: khellin

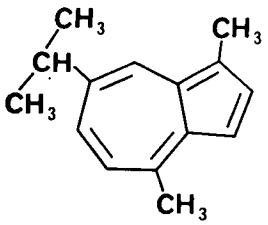


CXXXVI: plumbagin

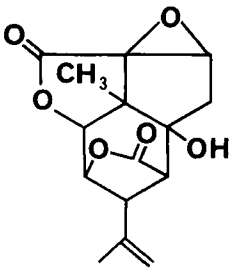
Structures of Nonalkaloid Principles Having Uterine Stimulant Activity



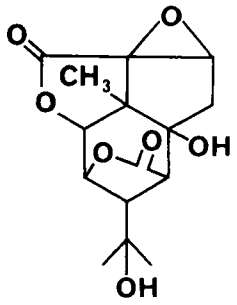
CXXXVII: camphor



CXXXVIII: guaiazulene

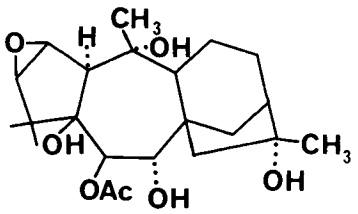


(*a*)



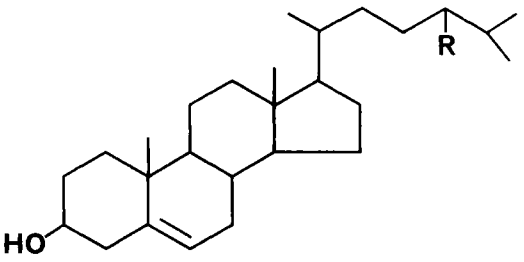
(*b*)

CXXXIX: picrotoxin (mixture of *a* and *b*)

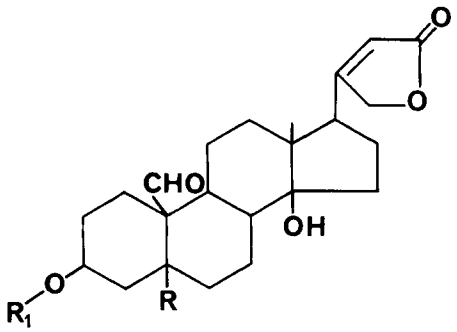


CXL: lyoniatoxin

Structures of Nonalkaloid Principles Having Uterine Stimulant Activity

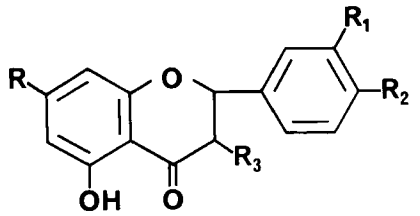


CXLI: cholesterol, R = H
CXLII: β-sitosterol, R = CH_2CH_3

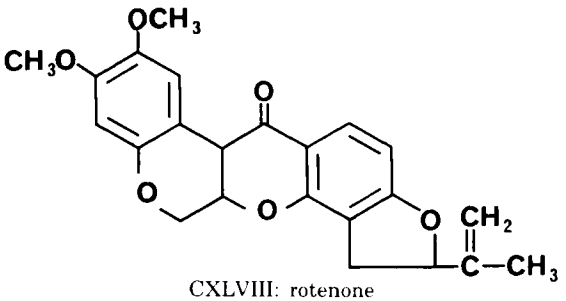


	R	R_1
CXLIII: strophanthin	OH	rhamnose
CXLIV: thevetin	H	thevetose-gentiobiose

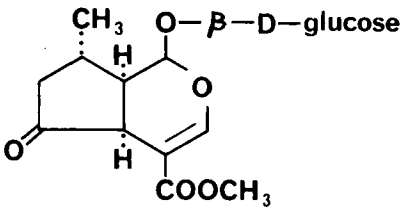
Structures of Nonalkaloid Principles Having Uterine Stimulant Activity



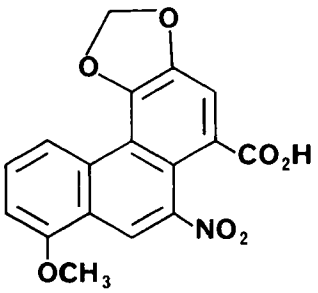
	R	R_1	R_2	R_3	other
CXLV: hesperidin	OH	OH	OH	OH	$\Delta^{2,3}$
CXLVI: quercetin	Rham·Glu	OCH_3	OCH_3	H	–
CXLVII: rutin	OH	OH	OH	*O*-rutinose	$\Delta^{2,3}$



CXLVIII: rotenone

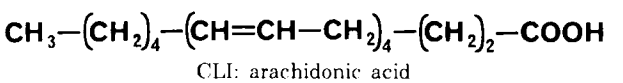


CXLIX: verbenalin

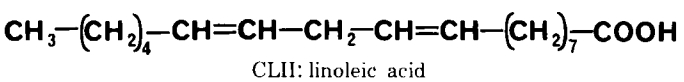


CL: aristolochic acid

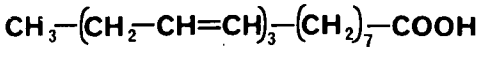
Structures of Nonalkaloid Principles Having Uterine Stimulant Activity



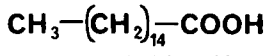
CLI: arachidonic acid



CLII: linoleic acid



CLIII: linolenic acid



CLIV: palmitic acid

Structures of Nonalkaloid Principles Having Uterine Stimulant Activity

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